MASSACHUSETTS WATER RESOURCES AUTHORITY

Secondary Treatment Facilities Plan

VOLUME III
TREATMENT PLANT
Appendices

Final Report
March 31, 1988

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List of Appendices

Secondary Treatment Facilities Plan

Volume III

Appendix A
Inventory/Inspection

APPENDIX A
INVENTORY/INSPECTION

Appendix A, the Inventory and Inspection of existing conditions at Deer Island, Nut Island and the remote headworks includes a detailed description and photographs of the existing facilities and is available for review at the Massachusetts Water Resources Authority in Charlestown, at Camp Dresser & McKee in Boston, and at Stone & Webster Engineering Corporation in Boston.

Secondary Treatment Facilities Plan

Volume III

Appendix B
Sampling Program & QAQC

Notes on the QA/QC Plan

The accompanying Quality Assurance Plan for sampling (QA/QC) was compiled in August of 1986 and distributed to the State, EPA, and MWRA for comment.

The described protocol was utilized for the fall 1986 sampling. A second round of sampling included within the QA/QC document for the spring of 1987 was conducted in accordance with the QA/QC plus revisions engendered by the results obtained in the fall. These revisions are detailed in Section 13 of this document.

A summary of the sampling results is given in Volume III, Section 6.1 of the report. The complete sampling results are contained within a four volume set that is on file at MWRA.

APPENDIX B

SAMPLING PROGRAM
QUALITY CONTROL/QUALITY ASSURANCE PROGRAM

1.0 INTRODUCTION

The Wastewater and Air Sampling Program is an integral part of the Massachusetts Water Resources Authority's (MWRA) Secondary Treatment Facilities Plan (STFP) and Residuals Management Facility Plan (RMFP). The purpose of the Sampling Program is to obtain representative wastewater and air samples and then to maintain the integrity of the collected constituents. This document identifies the quality control and quality assurance steps required to achieve these goals. This document is structured in accordance with EPA's May 1984 "Guidance for Preparation of Combined Work/Quality Assurance Project Plans for Environmental Monitoring."

The references cited in this manual present the most effective and current laboratory analysis and field sampling practices. The procedures and techniques described are by no means the only methods available, but are those which are to be followed in this sampling project. Camp Dresser & McKee's (CDM) Laboratory standard of practice is available upon request. All methods not included in CDM's standard of practice are clearly explained in this document and have been developed by CDM personnel who have had experience in sampling and laboratory analysis.

2.0 PROJECT DESCRIPTION

2.1 GOALS

The sampling program is designed to produce data that can be used for three primary goals:

1. Evaluation of wastewater treatment plant processes exclusive of residuals (sludge) treatment, and inclusive of evaluation of outfall sites, nutrient potential, and conventional discharge permit parameters. This data will be used by the DIFP.

2. Evaluation of residual treatment and disposal alternatives by the RMFP. At this time, the RMFP is collecting data only on the wastewater, including parameters such as total solids, metals, and priority pollutants.

3. Evaluation of air quality impacts, primarily focusing on the expected level of VOC emissions and the odor potential of the wastewater.

2.2 SAMPLING LOCATIONS

There are 6 influent sampling locations, 5 effluent sampling locations, and 3 air sampling locations that will be utilized. The use of each sampling location will be dependent upon both the type of sample being collected and the expected usage of the data from that portion of the sampling programs. The sampling locations are as follows:

South System Wastewater Sampling:

Influent to Nut Island Treatment Plant
Effluent from Nut Island Treatment Plant
(Prior to Chlorination)

North System Wastewater Sampling:

Influent to Columbus Park Headworks
Influent to Chelsea Creek Headworks
Influent to Ward Street Headworks
Influent to Winthrop Terminal Headworks
Influent to the Deer Island Plant
Effluent from the Columbus Park Headworks
Effluent from the Chelsea Creek Headworks
Effluent from the Ward Street Headworks
Effluent from the Deer Island Plant
(Prior to Chlorination)

North System Air Sampling:

Columbus Park Tunnel Shaft
Chelsea Creek Tunnel Shaft
Ward Street Tunnel Shaft

The samples collected simultaneously from the four North System Headworks, when totaled, are equivalent to an influent sample to the Deer Island plant.

The sampling program will be divided into two flow periods. The first period will be 28 days in the late summer/early fall of 1986, and the second period will be 14 days in the spring of 1987. The late summer/early fall period was selected to give parameter values during a low groundwater period and the spring period was selected to monitor parameters during a high groundwater period.

2.3 STATEMENT OF SCOPE

2.3.1 BOD_5, TS, TSS, SETTLEABLE SOLIDS AND CHLORIDES

The conventional parameters, BOD_5, TS, TSS, Settleable Solids, and Chlorides will be sampled at the influent to the four North System Headworks, and the influent to the two plants for 28 days in the first period and for 14 days in the second period. Samples will be collected as twenty-four hour composites and will be collected simultaneously.

These conventional parameters will also be sampled from the plant effluent for four days.

The data is primarily intended for the DIFP, but will also be utilized by the RMFP.

2.3.2 pH

The conventional parameter, pH, will be sampled at the North System Headworks for 3 days and for the following 25 days at the influent to the Deer Island plant, for a total of 28 days of
sampling in the initial period. pH grab sampling will also be done at the influent to the Nut Island plant for the entire 28 days. In the second sampling period, pH will be sampled for 14 days at the influent to each of the plants.

Past data indicates that there is not a large fluctuation in pH levels at either plant. Therefore pH readings will be primarily taken upon delivery to the lab and will be supplemented by a limited program of grab samples at the collection sites.

2.3.3 OIL AND GREASE

The conventional parameter, oil and grease, will be sampled for a total of 14 days. All oil and grease samples will be during the first period. For the North System, grab samples will be collected at the headworks for 3 days and at the plant influent for the remaining 11 days. Samples will be taken for 14 days at the influent to the Nut Island plant. The data is primarily intended for the RMFP needs but will also be utilized by the DIFP.

2.3.4 PRIORITY POLLUTANTS, HSL ORGANICS, AND ORGANIC SCANS

Samples will be collected and then analyzed for Priority Pollutants (PP) including Hazardous Substance List (HSL) Organic Compounds. There are four distinct subsets under this category as follows:

o Priority Pollutant List of PCB/Pesticides
o Priority Pollutant and HSL List of Acid/and Base/Neutral (A-B/N) Extractables
o Priority Pollutant List of Metals, Plus Boron Molybdenum and Cyanide
o Priority Pollutants and HSL List of Volatile Organics

The PCB/Pesticides and Acid/Bases will be 24-hour flow composites, sampled during the first period at the influent to each of the North System Headworks for 3 days, and then at the influent to the Deer Island plant for the next four days, for a total of 7 days of samples. For the entire 7-day period, the influent to Nut Island will be sampled. For four days during that time, effluent samples will also be collected from both the Deer and Nut Island plants, to be used in conjunction with the Whole Effluent Toxicity (WET) program. The influents to the two plants will be sampled again for a total of 5 days during the second sampling period.

Twenty-four-hour composite sampling for priority pollutant metals will be done at the influent to the North System Headworks for three days, and the influent to the Deer Island plant for the next four days, for a total of seven continuous days. Samples will also be collected for the Nut Island influent for seven days. For four days, in conjunction with the WET program, effluent samples will be collected from both plants. After day seven, metal samples will be

collected an additional 11 times at the plants' influent, for a total of 18 days of metal samples in the first period. During the second (spring) period an additional 10 days of metal samples are to be collected from each plant's influent.

For Volatile Organics Analysis (VOA), the samples are required to be grab samples. The samples will either cover a 24-hour period during which 4 samples will be collected at 6-hour intervals, or a 12-hour period during which 2 samples will be collected at 6-hour intervals.

For the three remote headworks on the North System (Columbus Park, Chelsea Creek, and Ward Street), the VOA grab samples will be taken at both the influent and effluent of the headwork structure four times daily for 5 days, and then twice daily for three days thereafter. This will produce 26 total data points. The VOA samples at the headworks are intended to quantify VOA emission levels. However, due to an inability to collect a water sample off the wastewater as it directly enters the tunnel shaft at these three sites, there will be concurrent air monitoring for VOAs at these shaft locations. The sum of wastewater VOA and tunnel shaft air VOAs will then be compared to determine the estimated emission levels.

For the influent to the Winthrop Terminal Headworks, and the Nut Island influent, VOA samples will be collected four times daily for five days. During that five day sampling period, the effluents from both plants will also be sampled four times daily for VOAs.

For one daily sample at each site, the analysis will include identification of the twenty largest compounds that are at least 25 percent of the internal standard under the VOA and Acid/Base/Neutral portions, during the analytical scan. Samples will be screened for these additional compounds for the three days samples are collected from the North System Headworks; for the four days that samples are collected at the Deer Island plant influent; for the seven days of influent samples at the Nut Island plant; and the four days of effluent sampling at both plant sites.

2.3.5 COD/TOC, VSS, TS, TKN AND TOTAL PHOSPHORUS

The samples will be twenty-four hour flow composites collected daily. The program will collect samples for analysis of the process parameters COD/TOC, VSS, TS, TKN, and total phosphorous from the influent to the two plants for 14 days during the first period and for two days during the second period.

The analysis of COD and/or TOC is much more rapid than that for BOD_5. It is normally possible to establish a proportional relationship between these parameters so that if one is known the other two can be extrapolated. Therefore, during the first days of the sampling program both BOD_5 and COD or TOC will be measured. Once the relationship is clearly established, from that point onward, only the COD or TOC analysis will be run. If after the relationship is established, an individual sample results in a COD or TOC reading that, in the opinion of the lab chemist, is abnormally high or low, then a BOD_5 analysis will be run on a duplicate sample.

The samples will also be analyzed for ammonia nitrogen for four days in the first period and

for two days in the second period.

2.3.6 SULFIDES

One other process parameter to be sampled is sulfides. The sulfide samples will be grab samples collected four times daily and then composited into a daily sample for analysis. Samples will be collected for four days at the remote headworks and the influents to the two plants during the first period, and for two days in the second period at the influent to the two plants.

2.3.7 HYDROGEN SULFIDE

Air sampling of hydrogen sulfide will occur at Columbus Park, Ward Street, and Chelsea Creek Headworks and at the Deer Island and Nut Island plant sites. A hydrogen sulfide monitor with continuous chart recorder will be located at the headworks' operational level to monitor the working air environment.

2.3.8 SPLIT SAMPLES

For six consecutive days, including one weekend day, a split sampling program will be conducted. The daily influent composite samples and grab samples taken at Deer Island WWTP will be split between CDM's lab and the lab at Deer Island WWTP. A similar split sampling program will be done with the Nut Island WWTP lab. CDM will also, if requested, provide DEQE with split samples from these two locations.

A split sampling program will also, if requested, be conducted by CDM and DEQE with influent samples from the Columbus Park, Chelsea Creek, and Ward Street remote headworks.

The following split sample parameters will be analyzed:

Parameter	Sample Type
BOD_5	24-hour composite
TSS	24-hour composite
Settleable Solids	24-hour composite
pH	Grab at 6-hour intervals - 4/day
Chlorides	24-hour composite
Oil & Grease	Grab at 6-hour intervals - 4/day

Each lab will receive approximately 1/2 gallon of the 24-hour composite and an oil and grease sample preserved in a separate container.

2.4 PURPOSE OF DATA

2.4.1 BOD_5, TSS, SETTLEABLE SOLIDS, pH

These conventional parameters are required by both the Deer Island and the Residuals Management Facility Plan as a basis for evaluating alternatives.

The plant effluent is sampled for these parameters in coordination with the Whole Effluent Toxicity testing (WET) that is part of the outfall siting work.

2.4.2 OIL & GREASE

This data is primarily intended for the RMFP needs, but will be utilized by the DIFP.

2.4.3 PRIORITY POLLUTANTS AND ADDITIONAL HSL COMPOUNDS

PCB/Pesticides and Acid/Base-Neutral

Based upon past data, the expected levels of PCB/Pesticides and Acid/Base Neutrals are not expected to be the controlling variable for either the DIFP or the RMFP. Since there is little recent data, the sampling program will analyze for these compounds. The PCB data are needed for the outfall siting needs of the DIFP. The data will also be used by the RMFP to evaluate the acceptability of treated sludge as regulated by Massachusetts Land Application Regulations.

Metals

The level of metals are expected to be one of the controlling parameters for both the RMFP and the outfall siting portion of the DIFP. Therefore, in addition to the priority pollutant metals, analysis will also be conducted for boron, molybdenum and cyanide compounds. The list of metals to be analyzed was determined based upon the Massachusetts Land Application Regulations for sewage sludge and compost.

VOA

One of the primary goals of the VOA sampling is to quantify the amount of VOCs presently volatilizing at a specific site. The determination of VOC air emissions based on wastewater analysis is experimental at this time. The program seeks to identify a usable relationship between wastewater and air sampling and analysis. Influent and effluent will be sampled, from which it is expected that a difference can be calculated. At the headworks, the VOC in the exhaust air from the tunnel shafts will also be sampled. The air sample results will be used in combination with the wastewater values to quantify VOCs at the headworks. Data will then be used by the DIFP to evaluate the need for, and the magnitude of, ozone precursor controls. Data will also be used for a screening of air toxics based upon the State's Chem/AAL guidelines.

2.4.4 COD/TOC, VSS, TS, TKN, TOTAL PHOSPHORUS, AMMONIA NITROGEN

This data will be used to evaluate treatment process design criteria. Criteria include the availability and level of nutrients present and needed to sustain biological treatment systems.

2.4.5 SULFIDES

The sulfide content of the wastewater will be used to evaluate both its treatability and its H_2S odor potential.

2.4.6 HYDROGEN SULFIDE

The purpose of continuously monitoring air levels of hydrogen sulfide at the headworks and the plants is to identify the operation periods when H_2S levels are maximum, to determine the time dependency of H_2S levels, to evaluate operator health and safety issues, and to provide a data base for proposed odor control equipment.

2.4.7 SPLIT SAMPLES

The purpose of the split sampling program is to evaluate the homogeneity of samples, to compare results from different laboratories, to establish the margin of error of a lab procedure, and to establish a connection/relationship between this sampling program and the sources of historical treatment plant data (Nut Island lab and Deer Island lab).

2.5 MONITORING NETWORK DESIGN AND RATIONALE

2.5.1 LOCATION RATIONALE

Samples taken at the Deer Island Treatment Plant influent will give parameter values that the proposed new plant site could experience. The reason for choosing the headworks sites is to determine by tributary components the loads from the MWRA system. Past data has been collected in the system; by industrial users; and as effluent data; but data has not been quantified for each tributary at the headworks.

2.5.2 HOMOGENEITY OF SAMPLES

Sampling procedures have been designed so that samples taken are representative of the entire volume of wastewater passing the sampling location. Actual sampling procedures are covered in Section 7.

2.6 MONITORING PARAMETERS AND ANALYTICAL METHODS

Tables B-1 through B-4 list all the parameters for which the wastewater will be analyzed. The type of sample, sampling orientation to the water surface, sampling frequency, and analytical method are also listed.

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY PARAMETER

Conventional Parameters	Sample Type	Water Surface (WS)[4] Sampling Orientation	Sampling[3] Frequency	Analytical Method
BOD 5 day	24 Hr Composite	Below WS	1/hr Min	507[1]
Total Solids	24 Hr Composite	Below WS	1/hr Min	160.3[2]
Total Suspended Solids	24 Hr Composite	Below WS	1/hr Min	160.2[2]
Total Volatile Suspended Sol	24 Hr Composite	Below WS	1/hr Min	160.4[2]
Settleable Solids	24 Hr Composite	Below WS	1/hr Min	209E[1]
Chemical Oxygen Demand	24 Hr Composite	Below WS	1/hr Min	410.4[2]
Total Organic Carbon	24 Hr Composite	Below WS	1/hr Min	415.2[2]
Chloride	24 Hr Composite	Below WS	1/hr Min	300[2]
Total Kjeldahl Nitrogen	24 Hr Composite	Below WS	1/hr Min	351.3[2]
Ammonia	24 Hr Composite	Below WS	1/hr Min	350.2[2]
Sulfide	Grab	Below WS	4/day	376.1[2]
Oil and Grease	Grab	Includes WS	4/day	413.1[2]
Total Phosphorus	24-Hr Composite	Below WS	1/Hr Min	365.2[2]
Total Nitrogen	24 Hr Composite	Below WS	1/hr Min	

[1] Standard Methods for the Examination of Water and Wastewater. 16th Edition. 1985.
[2] Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. March 1983.
[3] Samples are to be collected daily on a 24-hour flow composited basis at influent to headworks with a minimum sample collection of once per hour. Plant effluent samples will be time composited hourly and then each hourly sample will be flow composited based upon recorded flows that hour.
[4] Samples below water surface are samples collected from within the moving water and do not include any floating films.

TABLE B-2

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY METAL

Metals	Water Surface (WS) Sample Type	Sampling[2] Sampling Orientation	Analytical Frequency	Method[1]
Antimony	24 Hr Composite	Below WS	1/hr Min	204.2
Arsenic	24 Hr Composite	Below WS	1/hr Min	206.2
Beryllium	24 Hr Composite	Below WS	1/hr Min	210.2
Boron	24 Hr Composite	Below WS	1/hr Min	404.B[1]
Cadmium	24 Hr Composite	Below WS	1/hr Min	213.2
Chromium	24 Hr Composite	Below WS	1/hr Min	218.2
Copper	24 Hr Composite	Below WS	1/hr Min	220.2
Cyanide	24 Hr Composite	Below WS	1/hr Min	335.2[3]
Lead	24 Hr Composite	Below WS	1/hr Min	239.2
Mercury	24 Hr Composite	Below WS	1/hr Min	245.1
Molybdenum	24 Hr Composite	Below WS	1/hr Min	246.2[3]
Nickel	24 Hr Composite	Below WS	1/hr Min	249.2
Selenium	24 Hr Composite	Below WS	1/hr Min	270.2
Silver	24 Hr Composite	Below WS	1/hr Min	272.2
Thallium	24 Hr Composite	Below WS	1/hr Min	279.2
Zinc	24 Hr Composite	Below WS	1/hr Min	289.2

TABLE B-2

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY METAL
(Continued)

1 All methods contained in Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March, 1987.

2 Samples are to be collected daily on a 24-hour flow composited basis at influent to headworks with a minimum sample collection of once per hour. Plant effluent samples will be time composited hourly and then each hourly sample will be flow composited based upon recorded flows for that hour.

3 Standard Methods for the examination of Water and Wastewater, 16th edition, 1985.

TABLE B-3

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUNDS

Volatile Organic Compounds	Water Surface (WS) Sample Type	Sampling Orientation	Sampling[1] Frequency	Analytical Method
Priority Pollutants				
Chloromethane	Grabs	Includes WS	2 or 4/day*	40 CFR
Bromomethane	Grabs	Includes WS	2 or 4/day*	Part 136
Vinyl Chloride	Grabs	Includes WS	2 or 4/day*	Friday,
Chloroethane	Grabs	Includes WS	2 or 4/day*	Oct 26, 1984
Methylene Chloride	Grabs	Includes WS	2 or 4/day*	Method 624
Trichlorofluoromethane	Grabs	Includes WS	2 or 4/day*	
1,1-Dichloroethylene	Grabs	Includes WS	2 or 4/day*	
1,1-Dichloroethane	Grabs	Includes WS	2 or 4/day*	
Trans.-1,2-Dichloroethylene	Grabs	Includes WS	2 or 4/day*	
Chloroform	Grabs	Includes WS	2 or 4/day*	
1,2-Dichloroethane	Grabs	Includes WS	2 or 4/day*	
1,1,1-Trichloroethane	Grabs	Includes WS	2 or 4/day*	
Carbon Tetrachloride	Grabs	Includes WS	2 or 4/day*	
Bromodichloromethane	Grabs	Includes WS	2 or 4/day*	
1,2-Dichloropropane	Grabs	Includes WS	2 or 4/day*	
Trans-1,3-Dichloropropene	Grabs	Includes WS	2 or 4/day*	
Trichloroethylene	Grabs	Includes WS	2 or 4/day*	
Dibromochloromethane	Grabs	Includes WS	2 or 4/day*	
CIS-1,3-Dichloropropene	Grabs	Includes WS	2 or 4/day*	
1,1,2-Trichloroethane	Grabs	Includes WS	2 or 4/day*	

TABLE B-3

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUNDS
(Continued)

Volatile Organic Compounds	Water Surface (WS) Sample Type	Sampling Orientation	Sampling[1] Frequency	Analytical Method
Priority Pollutants				
Benzene	Grabs	Includes WS	2 or 4/day*	
2-Chloroethylvinylether	Grabs	Includes WS	2 or 4/day*	
Bromoform	Grabs	Includes WS	2 or 4/day*	
Tetrachloroethylene	Grabs	Includes WS	2 or 4/day*	
1.1.2.2-Tetrachloroethane	Grabs	Includes WS	2 or 4/day*	
Toluene	Grabs	Includes WS	2 or 4/day*	
Chlorobenzene	Grabs	Includes WS	2 or 4/day*	
Ethylbenzene	Grabs	Includes WS	2 or 4/day*	
Add'l Hazardous Substances List Compounds				
Styrene	Grabs	Includes WS	2 or 4/day*	
Total Xylenes	Grabs	Includes WS	2 or 4/day*	
Carbon Disulfide	Grabs	Includes WS	2 or 4/day*	
Vinyl Acetate	Grabs	Includes WS	2 or 4/day*	
2-Butanone	Grabs	Includes WS	2 or 4/day*	
Acetone	Grabs	Includes WS	2 or 4/day*	
2-Hexanone	Grabs	Includes WS	2 or 4/day*	
4-Methyl-2-Pentanone	Grabs	Includes WS	2 or 4/day*	

[1] Grab samples will be taken at 6-hour intervals. Selected days will be sampled four times over a 24-hour period. At other times samples over a 12-hour period will be sampled.

TABLE B-4

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUNDS

Acid/Base/Neutral Compounds	Sample Type	Water Surface (WS) Sampling Orientation	Sampling Frequency	Analytical Method
N-Nitrosodimethylamine	24 Hr Composite	Below WS	1/hr Min	40 CFR
Phenol	24 Hr Composite	Below WS	1/hr Min	Part 136
Aniline	24 Hr Composite	Below WS	1/hr Min	Friday,
Bis(2-Chloroethyl)Ether	24 Hr Composite	Below WS	1/hr Min	Oct 26, 1984
2-Chlorophenol	24 Hr Composite	Below WS	1/hr Min	Method 625
1,3-Dichlorobenzene	24 Hr Composite	Below WS	1/hr Min	
1,4-Dichlorobenzene	24 Hr Composite	Below WS	1/hr Min	
Benzyl Alcohol	24 Hr Composite	Below WS	1/hr Min	
1,2-Dichlorobenzene	24 Hr Composite	Below WS	1/hr Min	
2-Methylphenol	24 Hr Composite	Below WS	1/hr Min	
Bis(2-Chloroisopropyl)Ether	24 Hr Composite	Below WS	1/hr Min	
4-Methylphenol	24 Hr Composite	Below WS	1/hr Min	
N-Nitroso-Di-N-Propylamine	24 Hr Composite	Below WS	1/hr Min	
Hexachloroethane	24 Hr Composite	Below WS	1/hr Min	
Nitrobenzene	24 Hr Composite	Below WS	1/hr Min	
Isophorone	24 Hr Composite	Below WS	1/hr Min	
2-Nitrophenol	24 Hr Composite	Below WS	1/hr Min	
2,4-Dimethylphenol	24 Hr Composite	Below WS	1/hr Min	
Benxoic Acid	24 Hr Composite	Below WS	1/hr Min	
Bis(2-Chloroethoxy)Methane	24 Hr Composite	Below WS	1/hr Min	
2,4-Dichlorophenol	24 Hr Composite	Below WS	1/hr Min	
1,2,4-Trichlorobenzene	24 Hr Composite	Below WS	1/hr Min	
Naphthalene	24 Hr Composite	Below WS	1/hr Min	
4-Chloroaniline	24 Hr Composite	Below WS	1/hr Min	
Hexachlorobutadiene	24 Hr Composite	Below WS	1/hr Min	
P-Chloro-M-Cresol	24 Hr Composite	Below WS	1/hr Min	

TABLE B-4

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUNDS
(Continued)

Acid/Base/Neutral Compounds	Sample Type	Water Surface (WS) Sampling Orientation	Sampling Frequency	Analytical Method
2-Methylnaphthalene	24 Hr Composite	Below WS	1/hr Min	
Hexachlorocyclopentadiene	24 Hr Composite	Below WS	1/hr Min	
2,4,6-Trichlorophenol	24 Hr Composite	Below WS	1/hr Min	
2,4,5-Trichlorophenol	24 Hr Composite	Below WS	1/hr Min	
2-Chloronaphthalene	24 Hr Composite	Below WS	1/hr Min	
2-Nitroaniline	24 Hr Composite	Below WS	1/hr Min	
Dimethyl Phthalate	24 Hr Composite	Below WS	1/hr Min	
Acenaphthylene	24 Hr Composite	Below WS	1/hr Min	
3-Nitroaniline	24 Hr Composite	Below WS	1/hr Min	
Acenaphthene	24 Hr Composite	Below WS	1/hr Min	
2,4-Dinitrophenol	24 Hr Composite	Below WS	1/hr Min	
4-Nitrophenol	24 Hr Composite	Below WS	1/hr Min	
Dibenzofuran	24 Hr Composite	Below WS	1/hr Min	
2,4-Dinitrotoluene	24 Hr Composite	Below WS	1/hr Min	
2,6-Dinitrotoluene	24 Hr Composite	Below WS	1/hr Min	
Diethyl Phthalate	24 Hr Composite	Below WS	1/hr Min	
4-Chlorophenyl Phenyl Ether	24 Hr Composite	Below WS	1/hr Min	
Fluorene	24 Hr Composite	Below WS	1/hr Min	
4-Nitroaniline	24 Hr Composite	Below WS	1/hr Min	
4,6-Dinitro-2-Methylphenol	24 Hr Composite	Below WS	1/hr Min	

TABLE B-4

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUNDS
(Continued)

Acid/Base/Neutral Compounds	Water Surface (WS) Sample Type	Sampling Orientation	Sampling Frequency	Analytical Method
N-Nitrosodiphenylamine	24 Hr Composite	Below WS	1/hr Min	40 CFR
4-Bromophenyl Phenyl Ether	24 Hr Composite	Below WS	1/hr Min	Part 136
Hexachlorobenzene	24 Hr Composite	Below WS	1/hr Min	Friday.
Phenanthrene	24 Hr Composite	Below WS	1/hr Min	Oct 26. 1984
Anthracene	24 Hr Composite	Below WS	1/hr Min	Method 625
Di-N-Butyl Phthalate	24 Hr Composite	Below WS	1/hr Min	
Fluoranthene	24 Hr Composite	Below WS	1/hr Min	
Benzidine	24 Hr Composite	Below WS	1/hr Min	
Pyrene	24 Hr Composite	Below WS	1/hr Min	
Butylbenzyl Phthalate	24 Hr Composite	Below WS	1/hr Min	
3.3-Dichlorobenzidine	24 Hr Composite	Below WS	1/hr Min	
Benzo(A)Anthracene	24 Hr Composite	Below WS	1/hr Min	
Bis(2-Ethylhexyl)Phthalate	24 Hr Composite	Below WS	1/hr Min	
Chrysene	24 Hr Composite	Below WS	1/hr Min	
Di-N-Octyl Phthalate	24 Hr Composite	Below WS	1/hr Min	
Benzo(B)Fluoranthene	24 Hr Composite	Below WS	1/hr Min	
Benzo(K)Fluoranthene	24 Hr Composite	Below WS	1/hr Min	
Benzo(A)Pyrene	24 Hr Composite	Below WS	1/hr Min	
Indeno(1.2.3-C.D)Pyrene	24 Hr Composite	Below WS	1/hr Min	
Dibenzo(A.H)Anthracene	24 Hr Composite	Below WS	1/hr Min	
Benzo(G.H.I)Perylene	24 Hr Composite	Below WS	1/hr Min	

TABLE B-4

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUNDS
(Continued)

PCB/PESTICIDE ANALYSIS	Water Surface (WS) Sample Type	Sampling Orientation	Sampling Frequency	Analytical Method
Compound				
Aldrin	24 Hr Composite	Below WS	1 hr/Min	
Alpha-BHC	24 Hr Composite	Below WS	1 hr/Min	
Beta-BHC	24 Hr Composite	Below WS	1 hr/Min	
Gamma-BHC	24 Hr Composite	Below WS	1 hr/Min	
Delta-BHC	24 Hr Composite	Below WS	1 hr/Min	
Technical Chlordane	24 Hr Composite	Below WS	1 hr/Min	
4,4-DDT	24 Hr Composite	Below WS	1 hr/Min	
4,4-DDE	24 Hr Composite	Below WS	1 hr/Min	
4,4-DDD	24 Hr Composite	Below WS	1 hr/Min	
Dieldrin	24 Hr Composite	Below WS	1 hr/Min	
Endosulfan I	24 Hr Composite	Below WS	1 hr/Min	
Endosulfan II	24 Hr Composite	Below WS	1 hr/Min	
Endosulfan Sulfate	24 Hr Composite	Below WS	1 hr/Min	
Endrin	24 Hr Composite	Below WS	1 hr/Min	

TABLE B-4

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUNDS
(Continued)

Acid/Base/Neutral Compounds	Sample Type	Water Surface (WS) Sampling Orientation	Sampling Frequency	Analytical Method
PCB/PESTICIDE ANALYSIS				
Endrin Aldehyde	24 Hr Composite	Below WS	1 hr Min	40 CFR
Endrin Ketone	24 Hr Composite	Below WS	1 hr Min	Part 136
Heptachlor	24 Hr Composite	Below WS	1 hr Min	Friday.
Heptachlor Epoxide	24 Hr Composite	Below WS	1 hr Min	Oct 26. 1984
Methoxychlor	24 Hr Composite	Below WS	1 hr Min	Method 608
Arochlor 1016	24 Hr Composite	Below WS	1 hr Min	
Arochlor 1221	24 Hr Composite	Below WS	1 hr Min	
Arochlor 1232	24 Hr Composite	Below WS	1 hr Min	
Arochlor 1242	24 Hr Composite	Below WS	1 hr Min	
Arochlor 1248	24 Hr Composite	Below WS	1 hr Min	
Arochlor 1254	24 Hr Composite	Below WS	1 hr Min	
Arochlor 1260	24 Hr Composite	Below WS	1 hr Min	
Toxaphene	24 Hr Composite	Below WS	1 hr Min	

Table B-6 lists the parameters for which air from the headworks tunnel shafts will be analyzed. The type of sample, sampling frequency, and analytical method are also listed.

3.0 PROJECT FISCAL INFORMATION

This sampling program is one element of the Deer Island Facility Plan. The scope of work, budget, and funding for the Facility Plan are contained within a separate document titled "Detailed Work Plan for Deer Island Secondary Treatment Facilities Plan." The budgets and scope description of the sampling program can be found within Work Package FB-20C of that document.

4.0 SCHEDULE OF TASKS AND PRODUCTS

The task schedule for the sampling project is as follows:

Date	Task Description
July 15, 1986	Sampling site visit by CDM personnel.
July 25, 1986	Outline signal and power needs to MWRA.
August 8, 1986	Signal and power available at the sampling sites. Equipment installation starts.
August 11, 1986	Start of the trial sampling period.
August 13, 1986	First sampling period begins.
September 10, 1986	First sampling period ends.
October 30, 1986	First sampling period report data.
March 1, 1987	Begin second sampling period.
March 21, 1987	End second sampling period.
May 30, 1987	Second period sampling data available, final memo prepared.

TABLE B-6

AIR SAMPLE COLLECTION AND ANALYTICAL PROCEDURES BY COMPOUND

Volatile Organic Compounds	Sample Type[1]	Sampling[2] Frequency	Analytical[3] Method
Priority Pollutants			
Bromomethane	Grabs	4/day	2520
Vinyl Chloride	Grabs	4/day	1007
Methylene Chloride	Grabs	4/day	1005
1,1-Dichloroethylene	Grabs	4/day	1003
Trans.-1,2-Dichloroethylene	Grabs	4/day	1003
Chloroform	Grabs	4/day	1003
1,2-Dichloroethane	Grabs	4/day	1003
1,1,1-Trichloroethane	Grabs	4/day	1003
Carbon Tetrachloride	Grabs	4/day	1003
Trichloroethylene	Grabs	4/day	S336
Benzene	Grabs	4/day	1501
Bromoform	Grabs	4/day	1003
Toluene	Grabs	4/day	1501
Chlorobenzene	Grabs	4/day	1003
Ethylbenzene	Grabs	4/day	1501
Additional Hazardous Substances List Compounds			
Styrene	Grabs	4/day	1501
Total Xylenes	Grabs	4/day	1501
2-Butanone	Grabs	4/day	2500
Acetone	Grabs	4/day	1300
2-Hexanone	Grabs	4/day	1300
4-Methyl-2-Pentanone	Grabs	4/day	1300

[1] An initial screening using both Tedlar bag samples and NIOSH carbon adsorption/desorption samples will be collected and analyzed. Flow rates will be monitored also. A determination will be made as to accuracy of both methods, and the actual methods, and the actual samples will be run on selected method.

[2] Grab samples will be taken at 6-hour intervals.

[3] Analytical methods referenced are NIOSH methods. Results will be reported with percent recovery and carbon will be separately analyzed for front end and back end to monitor for breakthrough.

5.0 PROJECT ORGANIZATION AND RESPONSIBILITY

Figure B-1 shows the project organization chart.

In brief, each individual's role can be described as follows:

WILLIAM F. CALLAHAN (Senior Vice President/CDM): Monitors overall project to assure applicability of sampling to other tasks in the MWRA Facility Plan effort.

STEPHEN D. RAFFERTY (Project Manager/CDM): Has overall responsibility for the day-to-day sampling program.

DONALD MULDOON (Laboratory Manager/CDM): Overall responsibility for CDM lab work and outside laboratories.

JAMES F. OCCHIALINI (Laboratory Supervisor/CDM): Responsible for day-to-day CDM lab work. Author of lab portion of QA/QC plan.

LAB CHEMISTS - CDM has 10 chemists who will perform the sample analysis. Approximately 5 of the chemists will work exclusively on this project.

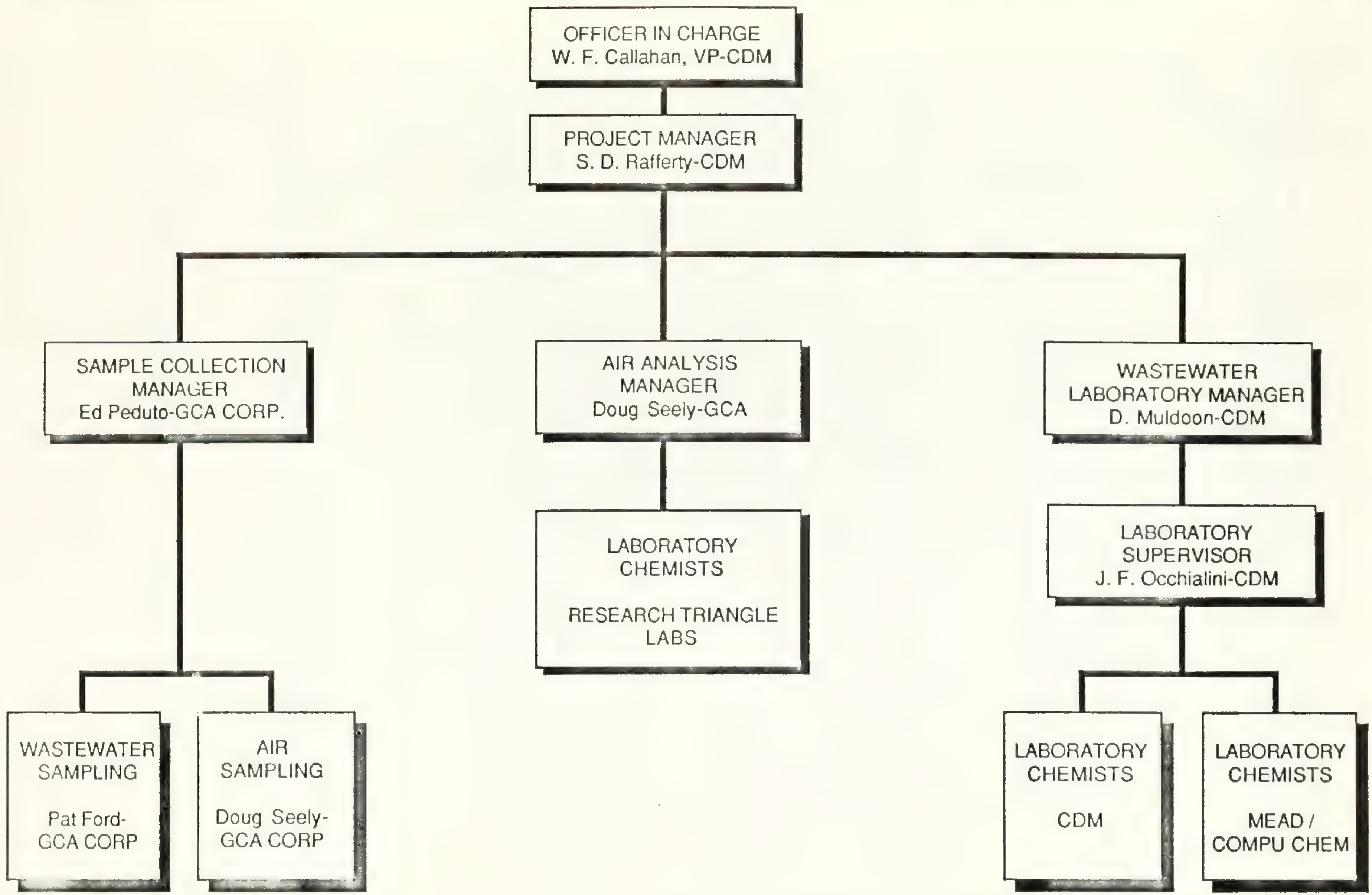
ED PEDUTO - (Project Manager/GCA Corp.): Directly responsible for GCA Corporation wastewater field sampling crews and will have day-to-day responsibility for monitoring sampling sites and equipment operation.

SAMPLING TECHNICIANS - GCA Corp. will employ between 8 and 12 technicians to perform the actual sampling.

DOUG SEELY - (Project Manager/GCA Corporation): Directly responsible for air sampling crews, forwarding of samples to Research Triangle Labs for analysis, and day-to-day monitoring of air sampling sites.

6.0 DATA QUALITY REQUIREMENTS AND ASSESSMENTS

A major requirement of every sampling and analytical plan is to assure that all data collected be of known quality. The concept of data quality refers to the level of uncertainty associated with a data set. This section specifies a level of data quality for each parameter being investigated that is consistent with the purpose of the sampling event and the use of the data. It is important to note that the assurance of proper data quality begins with the writing of the project's sampling and analytical plan, the adherence to the specified sampling Standard Operating Procedure (SOPs), sample custody procedures, laboratory QA/QC procedures, and ends with the data validation process.



MASSACHUSETTS WATER RESOURCES AUTHORITY

FIGURE B-1
SAMPLING PROGRAM - ORGANIZATION CHART

Data quality requirements are specified using the precision, accuracy, representativeness, completeness, and comparability (PARCC) criteria. The required method detection limits for each parameter are also specified at this time. A brief discussion of each PARCC parameter as it relates to the sampling and analytical plan follows.

Precision

The criterion of precision is a measure of the reproducibility of a given group of analyses under a given set of conditions. The overall precision of environmental monitoring data is the sum of the sampling precision and the analytical precision. Sampling precision is a function of the standard operating procedure used to collect the sample and the variability and/or homogeneity of the media being sampled. Analytical precision is a function of the procedure used, the analyst's technique, and instrument performance.

The best method to assess the overall precision of the entire sampling and analytical event is through the use of collocated samples. Collocated samples are independent samples collected in such a manner that they are equally representative of the parameter(s) of interest at a given point in space and time. The design of the MWRA sampling and analytical plan requires that the collocated samples be collected and processed by the same organization, thus providing precision information for the entire measurement system, including sample acquisition, homogeneity, handling, shipping, storage, preparation, and analysis. Collocated samples will be collected using side-by-side automatic samplers and simultaneous grab sampling techniques drawing from the same sampling location. Collocated samples will be included in the sampling and analytical program at a frequency of one per individual location.

Field replicated samples are the next best method of assessing the overall precision of the sampling and analytical program. Field replicated samples are samples obtained by dividing a sample into two representative portions immediately after the sample is taken. They provide precision information beginning with sample handling through shipping, storage, preparation, and analysis. Due to the inherent logistical problems associated with the collection of collocated samples, field replicated samples will provide the most precision information and will be included at a 5 percent frequency, or one per every twenty investigative samples. Field replicate data will be evaluated using criteria presented in Table B-7.

Laboratory (analytical) precision data obtained from laboratory replicates will be reported in the final laboratory report.

A split sample program using field replicated samples will also be coordinated with MWRA's existing influent and effluent sampling program. This split sample data will be evaluated for MWRA's internal use and will provide a source of inter-laboratory precision data for this project.

A split sample program using field replicated samples will also be coordinated with the Massachusetts DEQE, if requested.

TABLE B-7

QUALITY ASSURANCE OBJECTIVES

Parameter	Accuracy (% recovery of lab matrix spike or lab control sample)	Precision Field Replicate RPD (1)	QC Sample Frequency Blanks	Field Replicates	Collocated Samples
BOD5	Not Applicable	15	5%	5%	Min. 1/loc.
COD	85 - 115	15	5	5	Min. 1/loc.
TOC	85 - 115	15	5	5	Min. 1/loc.
Total Solids	Not Applicable	15	5	5	Min. 1/loc.
Total Suspended Solids	Not Applicable	15	5	5	Min. 1/loc.
Total Volatile Suspended Sol.	Not Applicable	15	5	5	Min. 1/loc.
Total Settleable Solids	Not Applicable	15	5	5	Min. 1/loc.
Chloride	80 - 120	15	5	5	Min. 1/loc.
Total Kjeldahl-N	80 - 120	20	5	5	Min. 1/loc.
Ammonia - N	80 - 120	20	5	5	Min. 1/loc.
Sulfide	85 - 115	15	5	5	Min. 1/loc.
Total Phosphorus	80 - 120	20	5	5	Min. 1/loc.
Oil & Grease	85 - 115	15	5	5	Min. 1/loc.
Priority Pollutant Metals	80 - 120	25	5	5	Min. 1/loc.
Priority Pollutant Volatiles	60 - 130	35	5	5	Min. 1/loc.
Additional HSL Volatiles	40 - 135	40	5	5	Min. 1/loc.
Semi-Volatiles	20 - 120	60	5	5	Min. 1/loc.
Pesticides/PCBs	45 - 125	40	5	5	Min. 1/loc.

1. Relative Percent Difference (RPD) is defined by the following equation:

$$RPD = \frac{D_1 - D_2}{(D_1 - D_2)/2} \times 100$$

where D_1 = First Sample Result
and D_2 = Second Sample Result (Duplicate)

A control limit of $\pm$ the detection limit will be used for sample values less than three times the reported detection limit.

Accuracy

Accuracy is a measurement of bias in a measurement system. Unlike precision, accuracy is difficult to measure for the entire measurement system. Sources of error that pertain to accuracy are the sampling process, field contamination, preservation, handling, sample matrix, calibration, and analysis. Accuracy will be monitored for this project by the use of field and laboratory blanks and matrix and surrogate spikes. Spike data will be reported as percent recovery.

The elimination of false positive and false negative values from the measurement system is the primary objective of the accuracy criterion, using both external program and laboratory QC. The potential for false positive values is monitored primarily by the use of field and laboratory blanks. The potential for false negative values is monitored through the use of spike recovery information.

The laboratory matrix spikes are used to document whether a sample exhibits any form of interference or matrix effect during the course of an analysis. A matrix effect is a phenomenon that occurs when the sample composition interferes with the analysis of the analyte(s) of interest. This can bias the sample result either in a positive or negative way, with the negative bias being the most common. Matrix spikes supply percent recovery information, which documents the magnitude of a matrix effect, and thus the amount of bias in the measurement system for that analyte. Percent recovery information can be used to adjust reported concentrations by the application of the appropriate correction factor or empirically to evaluate data with respect to some predetermined criteria. It is not recommended that sample values actually be adjusted for percent recovery unless a "worst case" scenario is being developed.

The frequency of inclusion and the types of QC samples used, as well as instrument calibration procedures, are documented in the laboratory's QA/QC plan. The plans are on file at each of the laboratories used. For wastewater, plans are at CDM Labs, One Center Plaza, Boston, MA; and CompuChem, 3308 Chapel Hill/Nelson Highway, P.O. Box 12652, Research Triangle Park, North Carolina, 27709. For air, the plans are at the lab at GCA Corp., 213 Burlington Road, Bedford, MA.

Representativeness

The criterion of representativeness expresses the degree to which sample data represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter that is most concerned with sampling program design.

Representativeness is best addressed by describing sampling techniques and the rationale used to select sampling locations. Sampling stations were primarily selected for this project so as to represent influent wastewater by headworks to ensure that no mass was lost in preliminary

treatment. The field locations for these samples have been verified by Mr. Stephen Rafferty.

Representativeness can be assured somewhat through the proper use of SOPs. Representativeness can be assessed to some degree by the use of collocated samples. By definition, collocated samples are collected so that they are equally representative of a given point in space and time. By evaluating the precision information obtained, an estimate of the variability at each location can be determined.

Completeness

Completeness is a measure of the amount of valid data obtained from a measurement program compared to the amount that was expected to be obtained under normal conditions. Completeness is usually expressed as a percentage. Access to the sampling location, sampling problems, analysis problems and the data validation process can all contribute to missing data. An overall completeness goal, expressed as a percentage, is 75 percent of the samples to be collected, to assure that enough data of sufficient quality are obtained from the measurement system to fulfill the objective of this study.

Critical Data Points (CDPs) should be identified in every completeness statement. CDPs are sample locations or times that valid data must be obtained in order for the sampling event to be considered complete, regardless of whether the overall completeness objective has been met.

Comparability

The criterion of comparability expresses the confidence with which one data set can be compared to another. The use of approved sampling and analytical SOPs and the reporting of analytical data in the appropriate units will satisfy this criterion. Seasonal variation attributed to the differences between the fall and spring sampling rounds will also be accounted for.

Reported Levels of Detection

The detection limits that will be reported for the parameters of interest are listed in Table B-8. The detection limits for metals and VOAs have been set at lower levels than routine lab practice because of the impacts that even low levels of these compounds may have on the DIFP and RMFP. It should be noted that matrix effects or high concentrations of some sample constituents may cause detection limits to be raised during analysis.

7.0 SAMPLING PROCEDURES

7.1 INTRODUCTION

This section discusses the field sampling techniques, describes the field equipment, and lists the preservative chemicals needed. Reference to laboratory methods of analysis are included in Tables B-1 through Table B-5 in Section 2.6.

TABLE B-8

REPORTED LEVELS OF DETECTION

CONVENTIONAL PARAMETERS

Parameter	(mg/l) Detection Limit
BOD 5-day	2
Total Solids	5
Total Suspended Solids	5
Total Volatile Suspended Solids	5
Settleable Solids	0.1
Chemical Oxygen Demand	10
Total Organic Carbon	0.1
Chloride	0.5
Total Kjeldahl Nitrogen	0.1
Ammonia	0.1
Sulfide	0.1
Oil and Grease	5
Cyanide	0.02

METALS ANALYSIS

Element	(μg/l) Detection Limit
Antimony	25
Arsenic	5
Beryllium	20
Cadmium	5
Chromium	5
Copper	5
Lead	5
Mercury	1
Nickel	5
Selenium	10
Silver	5
Thallium	10
Zinc	1
Boron	200
Molybdenum	50

TABLE B-8

REPORTED LEVELS OF DETECTION
(Continued)

VOLATILE ORGANICS ANALYSIS

Compound	(μg/l) Detection Limit
Priority Pollutants	
Chloromethane	10
Bromomethane	10
Vinyl Chloride	10
Chloroethane	10
Methylene Chloride	5
Trichlorofluoromethane	10
1.1-Dichloroethylene	5
1.1-Dichloroethane	5
Trans-1.2-Dichloroethylene	5
Chloroform	5
1.2-Dichloroethane	5
1.1.1-Trichloroethane	5
Carbon Tetrachloride	5
Bromodichloromethane	5
1.2-Dichloropropane	5
Trans-1.3-Dichloropropene	5
Trichloroethylene	5
Dibromochloromethane	5
CIS-1.3-Dichloropropene	5
1.1.2-Trichloroethane	5
Benzene	5
2-Chloroethylvinylether	5
Bromoform	5
Tetrachloroethylene	5
1.1.2.2-Tetrachloroethane	5
Toluene	5
Chlorobenzene	5
Ethylbenzene	5

TABLE B-8

REPORTED LEVELS OF DETECTION
(Continued)

Compound	($\mu g/l$) Detection Limit
Additional HSL Compounds	
Styrene	5
Total Xylenes	5
Carbon Disulfide	15
Vinyl Acetate	15
2-Butanone	15
Acetone	15
2-Hexanone	15
4-Methyl-2-Pentanone	15
HSL ACID BASE/NEUTRAL EXTRACTABLE COMPOUNDS	
N-Nitrosodimethylamine	20
Phenol	20
Aniline	20
Bis(2-Chloroethyl)Ether	20
2-Chlorophenol	20
1,3-Dichlorobenzene	20
1,4-Dichlorobenzene	20
Benzyl Alcohol	20
1,2-Dichlorobenzene	20
2-Methylphenol	20
Bis(2-Chloroisopropyl)Ether	20
4-Methylphenol	20
N-Nitroso-Di-N-Propylamine	20
Hexachloroethane	20
Nitrobenzene	20
Isophorone	20
2-Nitrophenol	20
2,4-Dimethylphenol	20
Benxoic Acid	100
Bis(2-Chloroethoxy)Methane	20
2,4-Dichlorophenol	20
1,2,4-Trichlorobenzene	20
Naphthalene	20
4-Chloroaniline	20
Hexachlorobutadiene	20

TABLE B-8

REPORTED LEVELS OF DETECTION
(Continued)

HSL ACID BASE/NEUTRAL EXTRACTABLE COMPOUNDS (Continued)

Compound	(μg/l) Detection Limit
P-Chloro-M-Cresol	20
2-Methylnaphthalene	20
Hexachlorocyclopentadiene	20
2,4,6-Trichlorophenol	20
2,4,5-Trichlorophenol	200
2-Chloronaphthalene	20
2-Nitroaniline	100
Dimethyl Phthalate	20
Acenaphthylene	20
3-Nitroaniline	100
Acenaphthene	20
2,4-Dinitrophenol	100
4-Nitrophenol	100
Dibenzofuran	20
2,4-Dinitrotoluene	20
2,6-Dinitrotoluene	20
Diethyl Phthalate	20
4-Chlorophenyl Phenyl Ether	20
Fluorene	20
4-Nitroaniline	100
4,6-Dinitro-2-Methylphenol	100
N-Nitrosodiphenylamine	20
4-Bromophenyl Phenyl Ether	20
Hexachlorobenzene	20
Phenanthrene	20
Anthracene	20
Di-N-Butyl Phthalate	20
Fluoranthene	20
Benzidine	100
Pyrene	20
Butylbenzyl Phthalate	20
3,3-Dichlorobenzidine	40

Note: The priority pollutant compounds 1,2-Diphenyl-Hydrazine, P-Chloro-M-Cresol, and 4,6-Dinitro-O-Cresol are not included on the Hazardous Waste Substance List and will not be reported.

TABLE B-8

REPORTED LEVELS OF DETECTION
(Continued)

HSL ACID BASE/NEUTRAL EXTRACTABLE COMPOUNDS (Continued)

Compound	($\mu g/l$) Detection Limit
Benzo(A)Anthracene	20
Bis(2-Ethylhexyl)Phthalate	20
Chrysene	20
Di-N-Octyl Phthalate	20
Benzo(B)Fluoranthene	20
Benzo(K)Fluoranthene	20
Benzo(A)Pyrene	20
Indeno(1,2,3-C,D)Pyrene	20
Dibenzo(A,H)Anthracene	20
Benzo(G,H,I)Perylene	20

PCB/PESTICIDE ANALYSIS

Aldrin	0.050
Alpha-BHC	0.050
Beta-BHC	0.050
Gamma-BHC	0.050
Delta-BHC	0.050
Technical Chlordane	0.50
4,4-DDT	0.10
4,4-DDE	0.10
4,4-DDD	0.10
Dieldrin	0.10
Endosulfan I	0.050
Endosulfan II	0.10
Endosulfan Sulfate	0.10
Endrin	0.10
Endrin Aldehyde	0.10
Endrin Ketone	0.10
Heptachlor	0.050
Heptachlor Epoxide	0.050
Methoxychlor	0.50
Arochlor 1016	0.50
Arochlor 1221	0.50
Arochlor 1232	0.50
Arochlor 1242	0.50
Arochlor 1248	0.50
Arochlor 1254	1.0
Arochlor 1260	1.0
Toxaphene	1.0

7.2 FIELD SAMPLING PROCEDURES

This section outlines the sampling and preservation technique checklist to be followed by the sampling crews for the automatic wastewater samples and the wastewater grab samples. Steps are in the order that they will be followed.

There are six sites to be sampled. The procedure for each site will include the procedures listed herein as necessary for that site. The sites and procedures are as follows:

- Remote headworks: Columbus Park, Ward Street, and Chelsea Creek
  - Automatic flow composited 24-hour influent samples using Collins samples
  - Sulfide, pH, oil and grease influent grab samples
  - VOA influent and effluent grab samples
  - Tunnel shaft air samples
  - H_2S air samples
- Winthrop Terminal Headworks
  - Automatic flow composited 24-hour influent samples using Collins samples
  - Sulfide, pH, oil and grease influent grab samples
  - VOA influent grab samples
- Deer Island Plant Effluent
  - Time composited grab samples from sedimentation basin prechlorination effluent channels
  - Sulfide, oil and grease, pH grab samples
  - VOA grab samples
- Nut Island Influent
  - Automatic flow composited 24-hour influent samples using Collins samples
  - Sulfide, pH, oil and grease influent grab samples
  - VOA influent grab samples
  - H_2S air samples
- Nut Island Effluent
  - Automatic flow composited 24-hour influent samples using Collins samples
  - Sulfide, pH, oil and grease influent grab samples
  - VOA influent grab samples

There will be one time composite ISCO sampler maintained in standby status to be used in the event of a mechanical malfunction of any of the other automatic samples.

The daily composited samples will be collected from approximately mid-day to mid-day. Actual sample start and stop times will be staggered to account for the average travel time within the system.

Start times for the 24-hour composites will be as follows:

o	Ward Street	09:20 AM
o	Columbus park	11:05 AM
o	Chelsea Creek	11:35 AM
o	Winthrop Terminal	01:35 PM
o	Deer Island Influent	01:45 PM
o	Deer Island Effluent	03:00 PM
o	Nut Island Influent	01:45 PM
o	Nut Island Effluent	03:00 PM

Labeling Scheme

Sample bottles will be labeled with an identifying code. The code will be in the following format:

Client - Type - Location - Sample No.

The client is MWRA.
The type is WW for wastewater.

The location codes are given below for each of the 11 sample locations.

1.	CPI	=	Columbus Park Headworks Influent
	CPE	=	Columbus Park Headworks Effluent
	WSI	=	Ward Street Headworks Influent

WSE	=	Ward Street Headworks Effluent
CCI	=	Chelsea Creek Headworks Influent
CCE	=	Chelsea Creek Headworks Effluent
WTI	=	Winthrop Terminal Influent
DII	=	Deer Island Influent
DIE	=	Deer Island Effluent
NII	=	Nut Island Influent
NIE	=	Nut Island Effluent

Each sample collected at a given location will be assigned a sequential number. Samples collected at the same time and location will be given the same number.

As an example of the labeling system, the first 24-hour composite sample collected at the Columbus Park influent would be labeled MWRA-WW-CPI-001.

Grab samples for VOA would receive an addition label of A, B, C or D. The label MWRA-WW-CPI-002A would identify the first (A) grab sample on day 2 from Columbus Park influent. This is because the grabs represent samples from that instant of time, whereas the composite represents a sample for a 24-hour period.

7.2.1 PROCESSING OF THE FULL AUTOMATIC FLOW COMPOSITED SAMPLE

1. Sign in with the MWRA operator on duty with assigned responsibility.
2. Ask the MWRA operator what channels are scheduled for operation for the next 24 hours, record flow by hour for preceding 24 hours.
3. Turn off automatic sampler and record the time.
4. Open the sampler door.
5. Record any observed problems or questions about the condition of the sample or how the automatic sampler is running.
6. Examine sample bottle. Confirm that cap is clean.
7. Remove the sample bottle and put on the cap.
8. Label the bottle with the proper site identity code and sample description.
9. Visually check to see if the sampling tube is clogged, unclog, and/or replace if necessary.
10. Put the full sample bottle in the transportation cooler. Pack with ice.
11. Install a clean, empty sample bottle (rated for priority pollutants if required) in the sampler.
12. Close the door.
13. Turn on the automatic sampler and record the time.
14. Complete the chain-of-custody report.

7.2.2 AUTOMATIC SAMPLER CALIBRATION (to be done a minimum of once every three days)

1. Open sampler and insert a sample bottle.
2. Activate the sampler.

3. Record the time for three samples to go into the bottle, record the flow rate over that same time period.
4. Turn off the sampler.
5. Pour the collected sample volume into a graduated cylinder.
6. Compare the total volume of the three collected samples to the average flow rate over that period to determine if the sample is correctly flow compositing; if necessary adjust pulse counter and repeat steps one through five.
7. Install the glass sample bottle.
8. Set sampler for 24-hour operation.
9. Turn on sampler.

7.2.3 pH, OIL AND GREASE, SULFIDE, CYANIDE GRAB SAMPLES

1. Calibrate the pH meter.
2. At the same influent channel location as the automatic sampler sample chamber, use the grab sample device with a collection container attached to take a sample at the water surface being sure to collect any floating material.
3. Test the pH directly from the collection container.
4. Record the pH on the collection form.
5. Pour a sufficient size sample into the 1000-ml glass oil and grease sample bottle to fill to the top. (Surface matter is allowed.)
6. Following the preservation techniques for oil and grease samples, preserve the sample.
7. Pour a sufficient size sample into the 125-ml plastic sulfide sample bottle to fill to the top.
8. Following the preservation techniques for sulfides, preserve the sample.
9. Label the grab sample bottles and fill out the sample custody forms.

7.2.4 WASTEWATER VOA SAMPLES

1. At the designated influent or effluent, use the grab sample device with a 1-liter amber glass bottle attached to take a sample just below the water surface.
2. Record the time to the nearest minute.
3. Select vial for the volatile organics sample, remove cap and incline vial at about a 45° angle. (Note: Caps with orange colored septums should be examined carefully before using. If the shiny Teflon side of the septum faces away from the sample, discard vial and select another.)
4. Slowly fill vial with a portion of the 1-liter amber bottle grab sample. Avoid bubbling and spilling while pouring.
5. Fill vial completely making sure a meniscus is present above the top. Use the cap or pipette to add the few last drops to produce the meniscus. The meniscus will help in sealing the vial without producing an air bubble.
6. Carefully close the vial with the Teflon-lined screw cap, putting the cap perpendicularly on the vial. Avoid any contact with the underside of the septum. Make sure the cap is tightly screwed on.

7. Invert the vial and tap the screw cap to check for air bubbles. Any air bubbles would be seen rising to the top of the vial. If air bubbles are present, repeat steps 2 through 4 (throw vial away).
8. Make sure the vial is correctly labeled, place vial in styrofoam cup and place in the appropriate cooler after labeling the vials.
9. Repeat steps 1 through 6 for second sample.
10. Fill out sample sheets
11. Determine the total flow through all four channels, and using the detention time tables, figure out the detention time to the effluent channel sampling location.
12. This detention time added to the time from step 2 is when the VOA effluent grab sample should be taken.
13. At the effluent channel sampling location, use the grab sample device with a 1-liter amber bottle attached to take a sample just below the water surface
14. Repeat steps 2 to 11 above.

7.2.5 VOA AIR SAMPLES (to be done by GCA)

1. Simultaneously with the collecting of the effluent wastewater VOA sample at the headworks, the air VOA sample at the tunnel shaft exit will be taken.
2. Check for air leaks in the stove pipe and plywood platform.
3. Use one hand to, determine which direction the air is going in the stove pipe connected to the tunnel shaft. Only proceed if air is exiting the stove pipe.
4. Take the VOA air sample. At the same time, measure the velocity of air leaving the stove pipe.
5. Fill out the appropriate sample forms.

7.2.6 HYDROGEN SULFIDE AIR MONITORING

1. H_2S will be continuous monitoring, calibration will be bimonthly.
2. Check record.
3. If scheduled, calibrate meter.
   a. Connect 25 ppm calibration gas cylinder to sensor/sample.
   b. Adjust recorded speed from slow to high.
   c. Open calibration gas cylinder, read recorder, adjust to 25 ppm as necessary.
4. Change the pen or the chart if required.
5. Fill out the appropriate sample forms.
   (These steps to be expanded once the procedures are better known)

7.3 DESCRIPTION OF THE SAMPLING EQUIPMENT

7.3.1 COLLINS MODEL 42 AUTOMATIC SAMPLER

Three models of automatic samplers are utilized for the sampling program. The Collins Model 42 automatic sampler is priority pollutant rated, explosion-proof, and can accept a flow signal to automatically regulate the time between samples. It is semiportable and contains its own

refrigerator. Because of its explosion-proof quality, these samplers will be used at each of the remote headworks and at the Winthrop Terminal Headworks to sample the influent. A typical operating sequence is as follows:

- o Total flow signal in the range of 4 to 20 milliamps, enters sampler
- o Signal is converted to a pulse which represents the number of gallons that has passed through the facility at a given instant
- o The pulse is added to existing pulses on a pulse counter
- o When a predetermined number of pulses are reached, the compressor purges the sample line with air
- o A valve switches and the compressor draws 25 ml of sample into the 5 gallon glass bottle in a refrigerator in the sampler cabinet
- o Sequence of events are repeated until the sampler is turned off

7.3.2 ISCO MODEL 2100 TIME COMPOSITE SAMPLER

The ISCO Model 2100 sampler is priority pollutant rated, contains 24 glass sample bottles, and is refrigerated by placing a bag of ice in its insulated housing. This portable sampler will automatically fill a sample bottle once per hour at locations where it is impractical to furnish a flow signal. These sampling locations include the Deer Island Treatment Plant effluent and Nut Island Treatment Plant effluent. The sampler will also be used as backup in the event of failure of the flow composited samplers. The sampler will run on rechargeable batteries and the 24 sample bottles will be flow composited in the field. The sampling sequence is very similar to that of the Collins sampler with a peristallic pump replacing the air compressor.

7.3.3 ISCO MODEL 1680 FLOW COMPOSITE SAMPLER

A modified priority pollutant rated ISCO Model 1680 sampler will sample from the remaining two locations: the Deer Island and Nut Island Treatment Plants' influent. The sampler is modified in that its ring of 28 bottles have been replaced by one 2-1/2 gallon glass container. A sample will flow directly from the Teflon tube to this container as timed by a flow signal. The sampling sequence is as described above for the Collins sampler.

7.3.4 GRAB SAMPLING DEVICE

The grab sampling device is simply a mechanism that will guide a grab sampling container to a pre-specified location in the channel and hold it there against the current while the container fills.

7.4 FIELD NOTES

Careful documentation of both expected and unexpected events through field notes is as important as the actual collection of samples. Each sample location will have a loose leaf notebook that contains all the necessary instructions and forms required at that location. These forms are described in detail below.

7.4.1 COMPOSITE SAMPLE FORM

A form was used for samples that were flow composited in the field (Deer Island Treatment Plant influent and effluent). The following procedure was used:

1. Each hour, the instantaneous mgd is recorded by operators in the engine generator building control panel. Record the 24 hours on the composite sample form that corresponds to the automatic sampler sample bottles.

2. Divide the largest hourly instantaneous mgd into the volume of the smallest sample. This represents how many milliliters (ml) of sample is required per mgd.

3. For each hourly mgd, calculate the amount of sample that will be transferred to the composite sample container by using the value calculated in step 2.

4. Transfer the appropriate sample quantity to the composite sample container. Throw out any remaining sample contents from the individual 24 bottles.

5. Calculate the total volume in the composite sample container.

*** NOTE: A more accurate procedure to calculate the individual composite quantities is to average the instantaneous flow amounts shown on the flow recorder sheets in a period 1 hour prior to each time the sample was taken and substitute this number for the instantaneous flow amount mentioned in the above calculation. In fact, this is what the flow proportioning samplers do. The CDM Laboratory follows this method also. However, this method will not be used by the field crew because the other method is more simple and less likely to result in errors.

7.4.2 SAMPLING PROCEDURE CHECKLIST

Each day, the sampling crew will receive a work plan outline of the day's events. These outlines will refer to various sampling procedure checklists made from the sample procedures in Section 7.2. The outlines will also include any deviations from the procedures found in these checklists as well as special instructions required. After each item is completed, it should be checked off. At the end of the crew shift, the person in charge should also record the time of the shift and sign the checklist form.

8.0 SAMPLE CUSTODY PROCEDURES

8.1 CHAIN OF CUSTODY

The primary objective of the chain-of-custody procedures is to create an accurate written record that can be used to trace the possession of the sample from the moment of collection through its lab analysis.

Each sample is considered to be physical evidence from the Facility. The chain-of-custody procedures will provide documentation of the handling of each sample from the time it is collected until it is destroyed. This documentation will assure that each sample collected is of known and ascertainable quality.

A chain-of-custody record will be filled out for each sample type at each sampling location to maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory which will analyze the sample (which will then continue the chain of custody within their laboratory records). Each time the samples are transferred to another custodian, signatures of both the person relinquishing the sample and the person receiving the sample, as well as the time and date, will be collected to document the transfer.

A sample chain-of-custody record is shown in Figure B-2. Actual field forms will include two to three copies so that forms can be filled out simultaneously. The sampling team leader retains the original and his own copy and, one copy remains with the samples until they are received by the laboratory. If samples are split to different labs, a copy will go to each lab. Care must be taken that all copies are legible. If additional duplicate sheets are required, the person relinquishing the samples is responsible for filling out additional copies, or making reproductions. The original must be returned by the sampling team to CDM for MWRA project records; the sampling team will retain its copy.

The chain-of-custody record will be placed in a ziplock bag and be included with each sample delivery. All samples will be hand-delivered to the CDM Boston laboratory. If a sample is to be analyzed by a subcontracted laboratory, that sample will be shipped via overnight delivery in compliance with chain-of-custody procedures. For the whole effluent toxicity testing program, Battelle will collect effluent samples from CDM's Boston laboratory in compliance with chain-of-custody procedures.

8.2 LABORATORY CUSTODY PROCEDURES FOR WASTEWATER SAMPLES

The CDM laboratory has designated a sample custodian for all wastewater samples. In addition, the laboratory has set aside a secured sample storage area. This is a clean, dry, isolated room with sufficient refrigerator space that is securely locked from the outside.

Samples will be handled by the minimum possible number of persons.

Incoming samples will be received by the custodian who will indicate receipt by signing the

CHAIN OF CUSTODY RECORD

Camp Dresser & McKee Inc.

CDM

PROJECT NAME ____________________

PROJECT NUMBER ____________________

Field Log Book
Reference No. ______

SAMPLE NUMBER	DATE	TIME	SAMPLE LOCATION	SAMPLE TYPE	ANALYSES: EXTR ORG	VOA	PEST/PCB	TRACE METALS					NUMBER OF CONTAINERS	LOG BOOK PG NO	REMARKS

SAMPLED BY (SIGN) ______ / ______ / ______ / ______

RELINQUISHED BY (SIGN)	RELINQUISHED BY (SIGN)	RELINQUISHED BY (SIGN)	RELINQUISHED BY (SIGN)	RELINQUISHED BY (SIGN)
1 ______ DATE/TIME (/)	2 ______ DATE/TIME (/)	______ DATE/TIME (/)	4 ______ DATE/TIME (/)	5 ______ DATE/TIME (/)
RECEIVED BY (SIGN)	RECEIVED BY (SIGN)	RECEIVED BY (SIGN)	RECEIVED BY (SIGN)	RECEIVED BY (SIGN)
1 ______ DATE/TIME (/)	2 ______ DATE/TIME (/)	3 ______ DATE/TIME (/)	4 ______ DATE/TIME (/)	5 ______ DATE/TIME (/)

METHOD OF SHIPMENT	SHIPPED BY (SIGN)	RECEIVED FOR LABORATORY BY (SIGN)	DATE/TIME
______	______	______	(/)

LEGEND Original: Return to Sample Traffic Control Center   Copies: Ship with Samples

MASSACHUSETTS
WATER RESOURCES
AUTHORITY

FIGURE B-2
CHAIN OF CUSTODY RECORD

chain-of-custody record sheet accompanying the samples and retaining the sheet as a permanent record.

Immediately upon receipt, the custodian will place the samples in the sample room, which will be locked at all times except when samples are removed or replaced by the custodian. To the maximum extent possible, only the custodian will be permitted in the sample room.

The custodian will insure that all samples are properly stored, preserved and maintained.

Samples will be distributed to personnel who are to perform tests by the sample custodian under the direction of the laboratory supervisor.

The analyst will record information describing the sample, the procedures performed, and the results of the testing in the laboratory notebook or analytical worksheet. The notes will be dated, indicating who performed the tests, and will include any abnormalities that occurred during the testing procedure. The notes will be retained as a permanent record by the laboratory.

Only approved methods of laboratory analysis will be used.

Laboratory personnel are responsible for the care and custody of a sample once it is released to them.

The laboratory area is maintained as a secured area and is restricted to authorized personnel.

Once the sample analyses are completed, the unused portion of the sample, together with identifying labels and other documentation, is returned to the custodian. The returned sample is then retained in the custody room until permission to destroy the sample is received by the custodian.

Sample tags will be turned over to the laboratory supervisor and will be destroyed only upon his order. Samples will be destroyed only upon the order of the laboratory supervisor.

The sample custodian will acknowledge receipt of samples and initiate the chain-of-custody for samples which are delivered to the laboratory without applicable chain-of-custody documentation or with incomplete documentation. Sampling results for such samples will be reported with the following disclaimer:

Samples were received:

___ without proper chain-of-custody
___ deficient chain-of-custody

9.0 SAMPLE BOTTLE PREPARATION AND SAMPLE PRESERVATION

9.1 BOTTLE CLEANING PROCEDURES

Depending on the analyses to be performed and the nature of the samples being collected, the sample container must be treated according to specific procedures. For environmental samples, bottles should be washed as described in General Bottle Cleaning if: 1) they will be stored for later (not specified) usage, 2) they will be used for composite samples for a variety of routine analyses, 3) they will be used for routine analyses not requiring special preparation.

9.1.1 GENERAL BOTTLE CLEANING

Bottle Material: plastic or glass

Bottle Size: Dependent upon determinations required

Cleaning Reagents:

1. Phosphate-free detergent
2. Distilled water

Procedure:

1. Rinse bottles with tap water.
2. Soak bottles in detergent solution for approximately thirty minutes.
3. Scrub bottles with a brush.
4. Rinse bottles several times with tap water to remove the detergent.
5. Rinse bottles thoroughly, several times, with distilled water.

9.1.2 BOTTLE CLEANING FOR METALS DETERMINATION

Bottle Material: Usually polypropylene

Bottle Size: Usually 500 ml

Cleaning Reagents:

1. Detergents
2. 1.1 Nitric acid
3. Distilled water

Procedure:

1. Follow general bottle cleaning procedure.
2. Add 1:1 nitric acid to bottles, cap, and shake briefly.
3. Allow bottles to stand for approximately 30 minutes, shaking them intermittently.
4. Pour acid from bottles and rinse them with tap water.
5. Rinse bottles thoroughly, several times, with distilled water.

9.1.3 BOTTLE CLEANING FOR OIL & GREASE DETERMINATIONS

Bottle Material: Glass with Teflon-lined cap

Bottle Size: One liter

Cleaning Reagents:

1. Acid solution of 1+1 Nitric acid
2. Detergent
3. Distilled water
4. Freon-113

Procedure:

1. Follow general bottle cleaning procedure.
2. Rinse bottles (excluding caps) with acid solution.
3. Pour acid from bottles and rinse them with tap water.
4. Rinse bottles thoroughly, several times, with distilled water.
5. Rinse bottles with Freon-113.

9.1.4 BOTTLE CLEANING FOR EXTRACTABLE ORGANICS

Bottle Material: Glass with Teflon-lined cap

Bottle Size: Usually one gallon

Cleaning Reagents:

1. Detergent
2. Chromic acid cleaning solution
3. Distilled water
4. Pesticide-grade hexane

Procedure:

1. Follow general bottle cleaning procedure.
2. Fill bottles with chromic acid cleaning solution and allow to stand for a minimum of 1/2 hour.
3. Pour chromic acid cleaning solution from bottles and rinse them thoroughly with tap water.
4. Rinse bottles several times with distilled water.
5. Rinse bottles and caps two times with pesticide-quality hexane.

9.1.5 BOTTLE CLEANING FOR HAZARDOUS SAMPLES

Bottle Material: Glass with Teflon-lined cap

Bottle Size: 40 ml for tank for high-hazard samples, up to 500 ml (wide mouth) for others

Cleaning Reagents:

1. Detergent
2. Distilled water
3. Reagent-grade methanol

Procedure:

1. Follow general bottle cleaning procedure.
2. Rinse bottle with methanol.
3. Bake for one hour at 300^0 F.

9.2 PRESERVATION TECHNIQUES

9.2.1 PRESERVATION TECHNIQUE FOR TOTAL METALS

Chemical Preservative: Ultrex concentrated HNO

Procedure:

1. Use bottle specifically cleaned for metal determinations.
2. Add 5 ml of Ultrex concentrated HNO per liter of sample. This should reduce the pH to less than 2.

9.2.2 PRESERVATION TECHNIQUE FOR OIL AND GREASE

Chemical Preservatives: Conc. H_2SO_4 or HCL

Procedure:

1. Use bottle specifically cleaned for oil and grease determinations.
2. To avoid corrosion of oil-lined caps, preservative (Conc. H_2SO_4) should not be added to empty bottles prior to sampling, but should be added to samples as soon as possible after collection.
3. Add 5 ml of concentrated H_2SO_4 or HCL to one (1) liter of liquid sample. This should reduce the pH to less than 2.
4. Add 1 ml concentrated H_2SO_4 per 80 g of solid sample.

9.2.3 PRESERVATION TECHNIQUE FOR CYANIDE

Chemical Preservative: NaOH

Procedure:

Add 2 ml of 10 N NaOH per liter of sample. This should increase the pH to greater than 12.

9.2.4 PRESERVATION TECHNIQUE FOR PHENOLS

Chemical Preservative: $CuSO_4$, H_2SO_4 and H_3PO_4

Procedure:

1. Add 10 ml of a 100 g/l CuSO4 solution per liter of sample in order to attain a concentration of 1 g/l CuSO4, and acidify with H_2SO_4 to a pH of less than 4.
2. Add a sufficient volume (usually 5 ml per liter of sample) of 1:9 H_3PO_4 to lower the pH of the sample to less than 4.

9.2.5 H_2SO_4 PRESERVATION TECHNIQUE FOR COD AND ALL FORMS OF NITROGEN AND PHOSPHORUS

Chemical Preservative: H_2SO_4

Procedure:

Add 2 ml of concentrated H_2SO_4 per liter of sample. This should reduce the pH to less than 2.

9.3 LABORATORY SAMPLE HOLD TIMES

The preservation requirements and hold times for samples are summarized in Table B-9.

References for Section 9

1. U.S. EPA, 1979. Methods for the Chemical analysis of water and wastes. March, 1979. EPA-600/4-79-020.

2. A.P.H.A. 1975. Standard methods for the examination of water and wastewater. 14th ed.

TABLE B-9

SAMPLE PRESERVATION AND HOLD TIMES

Parameter	Preservative	Hold Time
Ammonia	Cool, 4° C	28 days
BOD	"	48 hours
COD	Cool, 4° C H_2SO_4 to pH<2	28 days
Chloride	None required	28 days
Cyanide Total	NaOH to pH>12	14 days
Kjeldahl Nitrogen	Cool, 4° C H_2SO_4 to pH<2	28 days
Trace Metals	HNO_3 to pH<1	6 months
Oil and Grease	Cool, 4° C H_2SO_4 to pH<2	28 days
Volatile Organics	Cool, 4° C	14 days
Acid/Base - Neutral Extractables	Cool, 4° C	7 days: until extraction 30 days after extraction
Pesticide/PCB	Cool, 4° C	7 days: until extraction 30 days after extraction
Total Organic Carbon	Cool, 4° C, H_2SO_4 to pH<2	28 days
Total Phosphorus	Cool, 4° C, H_2SO_4 to pH<2	28 days
Total Suspended Solids	Cool, 4° C	7 days
Total Settleable Solids	Cool, 4° C	7 days

10.0 DATA VALIDATION

Validation of MWRA analytical data will be performed on two separate levels: Internal Laboratory Data Validation and External Program Data Validation.

10.1 INTERNAL LABORATORY DATA VALIDATION

All analytical data produced by the CDM Boston laboratory is validated prior to its release. This validation is conducted routinely as part of the laboratory's internal quality control program, using the guidelines established in the CDM Laboratory QA/QC Plan.

Performance goals and quality control evaluation procedures are documented individually for each analytical procedure used. This information is located within the individual CDM analytical procedures, specific to each parameter analyzed.

In general, all laboratory data is reviewed as it pertains to calibration, instrument performance, blank analysis, replicate analysis, and matrix and surrogate recovery. Also, the data is reviewed for the reasonableness of the analytical result (for example, suspended solids result greater than the total solids result of a sample), calculation and transcription errors. Of greatest importance is the elimination of false positive and false negative results. This validation process is complete when the sample analyst and laboratory supervisor sign off on the analytical report.

10.2 EXTERNAL PROGRAM DATA VALIDATION

The sampling and analytical plan for the MWRA project has its own QA/QC plan, which is independent of the laboratory's. This plan covers both the sampling and analytical component of the total measurement system. As such, the QA/QC information generated by following the plan will reflect both laboratory and field sampling performance.

This sampling and analytical plan specifies the inclusion of blind blanks and duplicate samples into the analytical system. These QC samples are prepared by the sampling team so that their true identity is unknown to laboratory personnel and are submitted for analysis at a frequency of 5 percent for blanks and 5 percent for duplicate samples.

These external QC samples provide the majority of the information used to review the data from a program perspective. The precision of the field duplicates is assessed and compared to the performance goals stated in Section 6.0 of this document. Field blank data and reported detection limits are also reviewed. Also, the laboratory QA/QC information reported with the analytical data is evaluated at this time.

The output of this program data validation is a usability report which attests to the suitability of the data or its intended use. Recommendations are included in this report which qualify specific pieces of data (if required) so that the information is not used incorrectly by project engineers. These recommendations are usually in the form of qualifying a reported

value as an estimate rather than an absolute value or the rejection of some reported values because of field blank contamination.

11.0 PERFORMANCE AND SYSTEM AUDIT

Performance and systems audits are an essential part of every QA/QC plan. A performance audit independently collects measurement data using performance evaluation samples. A system audit consists of systematic, comprehensive review of the total data production process which includes on-site reviews of a field and laboratory's operational systems and physical facilities for sampling, calibration, and measurement protocols.

The audits conducted in support of the MWRA project serve three general purposes:

1. to determine whether a particular group has the capability to conduct the monitoring before the project is initiated;

2. to verify that the QA Project Plan and associated standard operating procedures are being implemented; and

3. to detect and define problems so that immediate corrective action can begin.

The CDM Boston laboratory participates in the U.S. EPA Water Supply (WS) and Water Pollution (WP) ongoing performance evaluations, which will serve as performance audits for this project.

Systems audits of the sampling and analytical portion of this project are the responsibility of the Quality Assurance Officer. The Quality Assurance Officer will present a schedule of when audits will be conducted and what each audit will cover. All audits will be conducted by individuals who are not directly involved in the measurement process and who are competent in the fields they are auditing.

A preliminary meeting will be conducted prior to initiating any system audit. During this meeting, the auditor will identify key personnel, define scope of audit, establish communication with field and laboratory staff, describe auditing plan and schedule, and set a date for completion along with a final briefing. The documentation required for audits includes a Quality Assurance Notice form and a Nonconformance Report.

12.0 CORRECTIVE ACTION PROGRAM

12.1 CORRECTIVE ACTION PROGRAM

The corrective action program in place during this phase of the MWRA project has the capability to discern errors or defects in the project implementation process.

The Quality Assurance Officer has the authority to make appropriate corrections and improvements as may be necessary in techniques and methods used by field and laboratory personnel.

Field and laboratory personnel are required to report to project management and the QA Officer any statistical data or other information that reflects a need for corrective action that should be implemented for a particular procedure or process.

Inspection steps taken during sampling, calibration and measurements should detect defects, malfunctions, or other problems which could jeopardize the sampling and analytical process and will trigger corrective actions to rectify the causes and stabilize the system.

13.0 SPRING SAMPLING SUPPLEMENT

13.1 INTRODUCTION

This section was a supplement to the QA/QC plan submitted in August of 1986 for the sampling of wastewater and air at the MWRA's Deer Island treatment plant, Nut Island treatment plant, and the headworks tributary to that system.

Unless otherwise noted, all procedures detailed in the August 1986 document will remain in effect for this element of the sampling program.

13.2 GOALS

The goal of the Spring Sampling Program was to collect and analyze representative samples from the MWRA system during the "wet weather" period. The wet weather period is defined as that period during which infiltration of groundwater has substantially altered the average daily flow conditions. The flows to the plants will be compiled for the two-month period prior to the start of sampling and for the period during the sampling.

Sampling will not start until the analysis of flows to the plant clearly indicate the influence of infiltration.

In addition to the types of samples and analysis included in the fall program, the spring program will include the collection of raw primary sludge at both treatment plants. The sludge will be analyzed for the presence of metals and PCBs. These analyses are for the RMFP's characterization of sludge.

The analysis of wastewater during the fall program resulted in the frequent reporting of values as being "below detection limits" for both metals analysis and for the Acid Base Neutral fraction. During the spring portion of the program the wastewater analysis is being modified, wherever possible, to lower wastewater detection limits.

13.3 SAMPLING SCHEDULE

Table B-10 outlines the proposed schedule for the spring program. The program is 14 days in length as originally proposed. For five of those days there will be sludge and VOC grab sample collection conducted at intervals over 24 hours.

TABLE B-10

SPRING SAMPLING PROGRAM SCHEDULE

SPRING SAMPLING SCHEDULE	SAMPLE DAY AND LOCATION (note: fall program ended with day 30) 31 32 33 34 35 36 37 38 39 40 41 42 43 44	COMMENTS	NO. OF SMPL
CONVENTIONAL PARAMETERS			
BOD5	--DII, NII, WSI, CCI, CPI, WTI ----------------------	No change from the original program as submitted	84
TSS	--DII, NII, WSI, CCI, CPI, WTI ----------------------	in the Q/A Q/C	84
SETTLEABLE SOLIDS	--DII, NII, WSI, CCI, CPI, WTI ----------------------	Detection limits and analytical procedures	84
CHLORIDES	--DII, NII, WSI, CCI, CPI, WTI ----------------------	unchanged	84
pH	--DII, NII, WSI, CCI, CPI, WTI ----------------------		84
PROCESS PARAMETERS			
COD	DII DII NII NII		4
VSS	DII DII NII NII	No change from the original program as submitted in the Q/A Q/C	4
TOTAL SOLIDS	DII DII NII NII	Detection limits and analytical procedures unchanged	4
TKN	DII DII NII NII		4
TOTAL P	DII DII NII NII		[illegible]
AMMONIA NITROGEN	DII DII NII NII		[illegible]
SULFIDES	DII DII NII NII		4
METALS		Detection limits are being	
WASTEWATER TOTAL METALS	DII DII DII DII DII DII DII DII DII DII NII NII NII NII NII NII NII NII NII NII	lowered, see attached list for detection limit goals. Lowered limits for outfall and RMFP needs. Soluable metals	20
WASTEWATER SOLUABLE METALS	DII DII DII DII DII NII NII NII NII NII	added for RMFP needs.	10
SLUDGE TOTAL METALS	DII DII DII DII DII NII NII NII NII NII	Sludge samples requested for RMFP needs. Samples to be collected in accordance with	10
SLUDGE SOLUABLE METALS	DII DII DII DII DII NII NII NII NII NII	protocol as outlined in the local limits study. Analysis to conventional detection limits. Soluable is a non-standard procedure	10
ACID-BASE/NEUTRAL, PESTICIDES AND PCBs in WASTEWATER	DII DII DII NII NII NII	Program similar to original Q/A Q/C.	6
PCBs in SLUDGE	DII DII DII NII NII NII	Added per RMFP request. Analysis and limits as per original Q/A Q/C	6
VOLATILE ORGANICS		At request of air emmission evaluation samples are being	
PP & HSL VOCs with search twice/day	DII DII DII DIE DIE DIE DIECDIECDIEC NII NII NII	both prechlorination (DIE) and postchlorination (DIEC). Sample days reduced from 5 to 3.	24
ORGANIC SPECIATION	DII DII NII NII	Speciation analysis by capillary GCMS for organic groups including Hydrocarbons, Amines, Aldehydes, Sulphu including flame ionization detec	

13.4 SAMPLING LOCATIONS

13.4.1 SLUDGE

The sludge sample from Deer Island will be collected after thickening and prior to digestion. The samples will be collected from sampling taps located in the pump rooms in the basement of the Sludge Thickener Building. Sampling will be rotated among the thickeners in service. A sample will be taken every four hours.

The sludge sample from Nut Island will be collected from sampling taps at one of two pumps which are operated in each of the three pump houses. Samples will be taken first at Pump House No. 1, then 3 hours later at Pump House No. 2, then four hours later back at Pump House No. 1 etc. These are the same locations as originally defined and utilized by Black and Veatch during the MWRA's Local Limits study.

13.4.2 WASTEWATER

All influent wastewater sampling locations remain the same as used in the fall program.

VOC effluent samples at Deer Island will be taken from two locations. Prechlorination VOC samples will be taken from the effluent end of the primary sedimentation basins, prior to passing over the weir into the effluent channel. These samples will be tagged as DIE. Postchlorination VOC samples will be collected from the sampling tap located in the process water building downstream of the point where the effluent channel discharges into the outfall pipeline. These samples will be tagged as DIEC. The purpose of sampling pre- and post-chlorination is to evaluate the release of VOCs during agitation occurring as the effluent drops from the effluent channel into the outfall pipeline.

13.5 SAMPLE COLLECTION AND ANALYTICAL PROCEDURE

13.5.1 WASTEWATER METALS

Table B-2 of the QA/QC, "Sample collection and analytical procedures by metal," is being modified for wastewater sample collection and analysis in accordance with Table B-10. (The detection limits for sludge samples will remain at the limits established in Table B-2) This table outlines the goals for detection limits that are being set for the Spring Sampling Program. These detection limit goals will be applied to both total metals and soluble metals for wastewater analysis. Table B-11 provides a listing of the fall detection limit goals, reference analytical procedure detection limits (the reference procedure is for clean water without matrix interference), and outlines the goals for the spring. In order to reach the established goal, the lab procedure is being modified to concentrate a larger volume of wastewater sample for analysis. Accordingly, the sample collection is being modified at the plant's influents to increase the sample volume collected.

Table B-11

MWRA SPRING 1987 SAMPLING PROGRAM
METAL ANALYSIS DETECTION LIMITS INFORMATION

METAL	Fall 87 Prev. Det. Limit ppb	Reference Standard Det. Limit Graphite Furnace[1]	Inductively Coupled[2]	Detection Limit Goal For Spring
Antimony	25.00			25.00
Arsenic	10.00	1.00	53.00	1.00
Arsenic IV	N/A	N/A	N/A	N/A
Arsenic III	N/A	N/A	N/A	N/A
Beryllium	20.00	0.20	0.30	0.20
Boron	200.00			10.00
Cadmium	5.00	0.10	4.00	0.50
Hexavalent Chromium	20.00	5.00	10.00	5.00
Trivalent Chromium	N/A	5.00		5.00
Copper	50.00	1.00	6.00	1.00
Lead	50.00	1.00	42.00	1.00
Mercury	1.00	0.20	1.00	0.20
Molybdenum	50.00	1.00		5.00
Nickel	20.00	1.00	15.00	1.00
Selenium	10.00	2.00	75.00	5.00
Silver	5.00	0.20	7.00	1.00
Zinc	2.00	0.05	2.00	2.00
Cyanide	20.00	20.00		5.00

(1) Methods for the Chemical Analysis of Water and Wastes EPA - 600/4-79-020.

(2) Inductively coupled - plasma emission spectroscopy prominent lines: EPA - 600/4-79-017.

13.5.2 SLUDGE METALS

The analysis of metals in the sludge will be done in accordance with the procedure outlined in Table B-2 of the QA/QC plan.

Past sampling and analysis during the local limits study has shown that the detection limits for metals established during the fall program are adequate for the detection of metals in sludge from the two plants. Sludge will not be analyzed to the detection limit goals established for spring wastewater. The analysis of sludge for total metals will be reported on a dry weight basis.

In addition to analyzing sludge for total metals, the sludge will also, if possible, be analyzed for soluble metals. The methodology for the separation of the soluble portion of the sludge sample is not a defined procedure and the ability to separate the solids portion of the sludge from the soluble portion will be dependent upon the quality of the sampled sludge. The following procedure will be utilized: the sample will be centrifuged to separate the major portion of the solid fraction; the decant portion will then be filtered through a 0.45 micron screen; and the filtered portion will be analyzed for soluble metals. This procedure assumes that the sludge is collected at between 3 and 7 percent solids in the field.

13.5.3 WASTEWATER VOLATILE ORGANIC COMPOUNDS (VOCs)

The VOCs will be sampled and analyzed as stated in Table B-3 of the QA/QC. During the Fall Sampling Program, one quarter of the samples were searched for the presence of other volatile compounds not listed on the priority pollutant list, or the hazardous substance list. A total of six additional compounds were identified through that search process. At the remote headworks air sampling for VOCs was conducted. Compounds were detected in the air analysis that were not detected in the wastewater analysis. These air compounds were generally detected in low concentrations in the air and fell into two categories; fluorodated hydrocarbons and gasoline components. During the spring sampling, additional analysis consisting of capillary GCMS and flame ionization detection of the wastewater grab samples for two days has been added to quantify the organic fractions of the wastewater that are likely to contain both the fluorodated hydrocarbons and the highly-volatile gasoline components.

13.5.4 ACID/BASE/NEUTRAL COMPOUNDS AND PCB/PESTICIDES

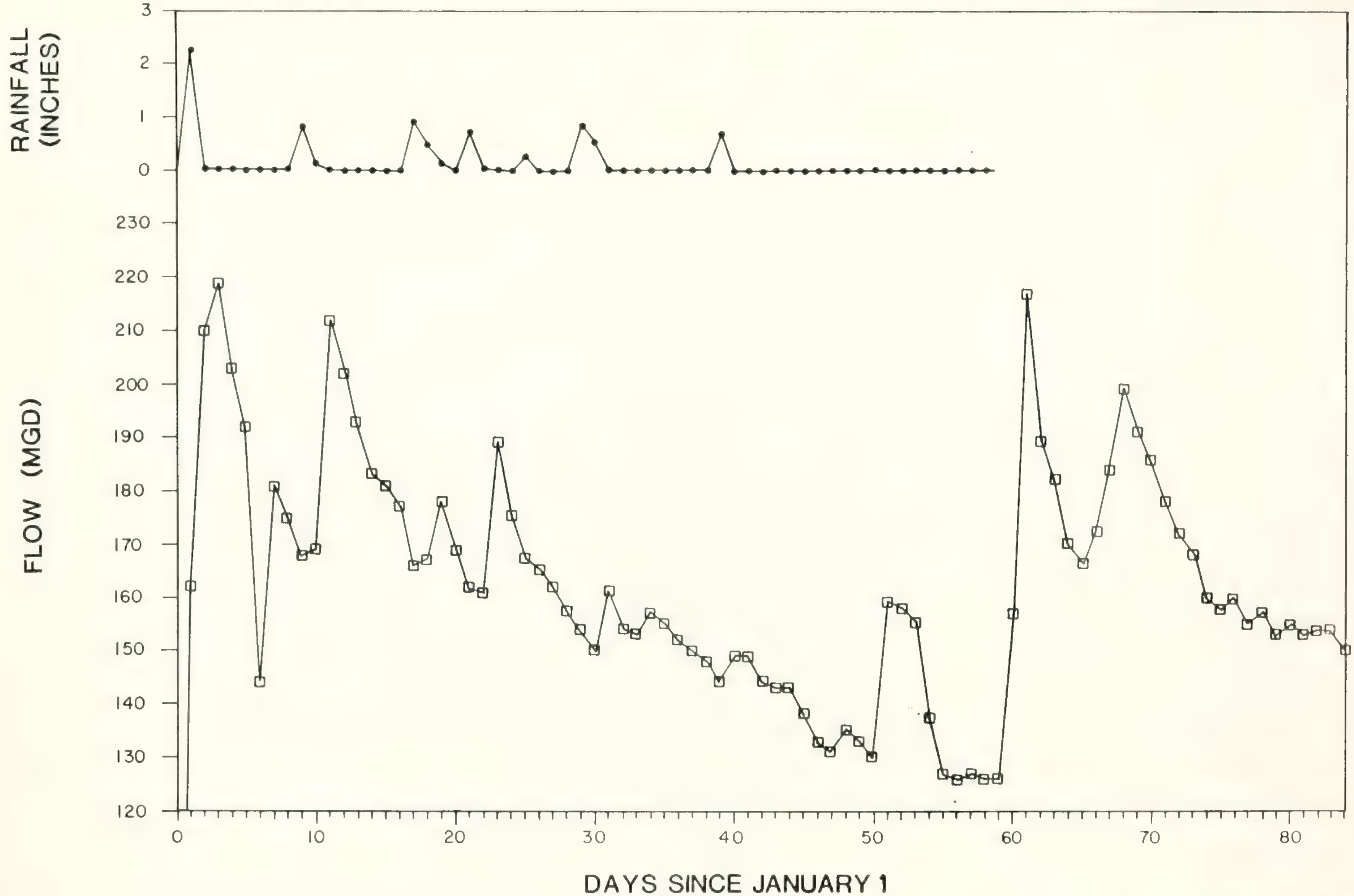
The collection and analysis for the Acid/Base/Neutral Compounds and the PCB/pesticides in wastewater will be essentially the same as those performed for the fall program. The analysis will be conducted by CompuChem, the same lab used for the analysis in the fall. It should be noted that the detection goals are equal to the limits utilized in the fall. There was an internal request to lower the detection limits. However, we were unable to locate labs that, as part of standard analysis, could achieve lower detection limits on the compounds from a wastewater sample.

13.6 SAMPLING PROGRAM INITIATION

The Spring Sampling Program will begin once there is a clear indication that groundwater infiltration is influencing the average daily flows in the system.

At Deer Island it is difficult to measure the influence of infiltration from the daily flow records. The facility has a limited number of operational pumps, and any flows in excess of the pumping capacity are "choked" or held upstream of the remote headworks. A review of the flow records and summary of hours choked since January 1, 1987, clearly indicates the difficulty in establishing a clear trend.

At Nut Island it is much easier to evaluate the impact of groundwater infiltration upon the system. The relationship between flow and rain events (and snow events converted to inches of rain) at Nut Island is portrayed in Figure B-3. The Figure provides flow information at Nut Island since January 1, 1987. Once the average daily flow, in the absence of rain events, rises above the base level of 160 MGSD, and remains above that level, the Spring Sampling program should begin.



MASSACHUSETTS
WATER RESOURCES
AUTHORITY

FIGURE B-3
NUT ISLAND WASTEWATER FLOWS
AND RAINFALL-SPRING 1987

Secondary Treatment Facilities Plan

Volume III

Appendix C
Unit Process Description

SECONDARY TREATMENT FACILITIES PLAN
VOLUME III
APPENDIX C
UNIT PROCESS DESCRIPTION

CONTENTS

APPENDIX C

CONTENTS

1.0 PRELIMINARY TREATMENT

1.1 SCREENING

The coarse screening operation is frequently the first operation in a wastewater treatment plant. The screening operation removes from the wastewater the solids and trash that may impact the performance of downstream treatment equipment and processes. Coarse screens also prevent large objects such as logs from damaging downstream equipment. The coarse screens to be considered for use for this project are bar racks and bar screens. The bar screens would consist of bars having a 3/4-inch openings and a raking or cleaning mechanism. The bar racks, also cleaned mechanically, would have 3-inch openings.

The types of screens investigated for use as either a bar rack or bar screen are described below:

1.1.1 CATENARY SCREEN

This screen's cleaning mechanism consists of tooth rakes attached to a chain forming a catenary loop in front of the screen. The catenary screen eliminates submerged sprockets, shafts, or bearings, thereby minimizing maintenance.

1.1.2 CLIMBER SCREEN

This screen also provides a front clean, front return mechanism with the motion of the rake following a direct up-down path similar to that of a man using a rake. This system does not have submerged moving parts. Also, when the system is not raking, there is no equipment below the water surface other than the screen bars.

1.2 GRIT REMOVAL

In wastewater, the term grit describes those particles having settling velocities much greater than the putrescible organic solids. Examples of solids that fall under the grit classification are gravel, sand, coffee grounds, and seeds. Grit should be removed early in the treatment process scheme to prevent clogging of pipes and channels and to protect mechanical equipment from unusual wear and abrasion.

The grit removal options studied during this screening report follow:

1.2.1 HORIZONTAL FLOW CHANNEL

The horizontal flow grit chamber is designed to maintain a constant velocity through the tank over a range of flows. Gates are used to control flow to each unit. A velocity of 1 fps will keep most of the organic material present in the wastewater suspended, and allow the heavier grit particles to settle. The grit is usually collected by a chain and flight mechanism, a screw conveyor, a pumping system, or a combination of these systems. In some instances an overhead clamshell bucket is used.

1.2.2 AERATED GRIT CHAMBER

An aerated grit chamber utilizes diffused air to induce a spiral velocity over a wide range of flow conditions. The air is supplied along one side of the chamber, generating a rolling motion in the water. The amount of air supplied determines the velocity of the roll, which controls the quantity of grit and organic material that is settled. The settled grit is swept along a sloped channel bottom by the rolling action to a hopper where it is collected. The grit may be collected by a chain and flight mechanism, a screw conveyor, a pumping system, or a combination of these systems. An overhead clamshell bucket system may also be used.

1.2.3 CENTRIFUGAL GRIT CHAMBER

These circular grit chambers use the combined action of centrifugal force and gravity to move incoming grit particles to the center of the chamber floor. The settled grit particles are collected in a central hopper by a screw conveyor or a pumping system. A circulating paddle may be used to impart the circular or vortex flow pattern during low flows, and to increase the particle velocity along the floor of the chamber, allowing resuspension of the lighter organic material. The centrifugal force is the result of an induced vortex water pattern created by the circular shape of the chamber.

1.2.4 CYCLONE PRIMARY SLUDGE DEGRITTING

The grit removal options discussed previously would be placed in the treatment process train prior to primary sedimentation. This alternative, primary sludge degritting, would remove grit from the wastewater as part of the primary sedimentation process. Dilute primary sludge containing grit would be passed through cyclone degritters to separate the grit from the primary sludge solids. The primary sludge must be fed to the cyclone degritters at a low solids concentration of 1/2 percent. The degritted primary sludge stream is commonly thickened prior to subsequent sludge processing.

1.3 PREAERATION

Preaeration of raw wastewater before primary sedimentation is practiced to enhance BOD and suspended solids removal in the primary sedimentation tanks. The effectiveness of the preaeration process to increase BOD and suspended solids removal is directly dependent on the detention time. The air supplied to the process keeps materials in suspension and evenly distributed, and also freshens the wastewater.

2.0 PRIMARY TREATMENT

2.1 PRIMARY CLARIFIER, RECTANGULAR

Primary clarification involves a relatively long period of quiescence in a basin where most of the settleable solids in a pretreated wastewater fall out of suspension by gravity. The solids are mechanically transported along the bottom of the tank by a scraper mechanism and pumped as a sludge underflow.

Scum floats to the surface and is usually collected at the effluent end of rectangular tanks by the flights returning at the liquid surface. The scum is then scraped manually up an inclined apron, or can be removed hydraulically or mechanically.

2.2 PRIMARY CLARIFIER, CIRCULAR

The circular clarifier is equipped with an influent feed that is well located in the center, which distributes the influent radially, and a peripheral weir overflow system that carries the effluent. A rotating mechanical scraper conveys sludge to a center hopper. Floating scum is trapped inside a peripheral scum baffle and scraped up an inclined apron into a scum discharge box.

2.3 PRIMARY CLARIFIER WITH CHEMICAL ADDITION

In this process, salts of calcium, iron, or aluminum are added to pretreated wastewater. Precipitated phosphorus, as well as considerable BOD and suspended solids, are removed from the system as primary sludge. The floc formed by the chemical increases suspended solids and associated BOD removals over those expected without chemicals and at the same overflow rate. Mixing and flocculation are needed for this process, and the primary basins must be modified for this.

2.4 TRAY CLARIFIERS

Tray clarifier units are similar to conventional rectangular clarifiers with the following differences. The units are stacked with wastewater entering the lower unit and traveling to the upper. No pumps are needed to lift the flow. Sludge is captured at the lower portion of each unit and is gravity fed to a hopper and to further sludge processing.

2.5 STACKED CLARIFIERS

Stacked clarifier units are similar to conventional rectangular units except that two clarifier units are constructed over one another. This saves approximately 40 percent of the total area

required for conventional rectangular clarifiers. Stacked clarifiers, unlike the tray-type units, have separate wastewater influent distribution and effluent collection facilities. Each stacked clarifier can be operated independently of the other. Sludge is captured at the lower portion of each unit and is gravity fed to a hopper for further sludge processing.

2.6 INCLINED TUBE SETTLERS

Inclined tube settlers are shallow settling devices consisting of bundles of small plastic tubes. The tubes are used to enhance the settling characteristics of sedimentation tanks and to decrease detention times. Tube shape, hydraulic radii, inclination, and length of the units vary according to the particular manufacturer. Typical practice is to insert modules of tube settlers in sedimentation tanks (either rectangular or circular) to sufficient depth. Flow within the clarifier passes upward through the tube and exits. The solids move downward counter-currently and out of the tube modules to the tank bottom by means of gravity.

3.0 SECONDARY TREATMENT

3.1 ACTIVATED SLUDGE, AIR

Activated sludge is a continuous flow biological treatment process characterized by a suspension of aerobic microorganisms, maintained in a relatively homogeneous state by the mixing and turbulence induced by aeration. The microorganisms oxidize soluble and colloidal organics to CO_2 and H_2O in the presence of molecular oxygen. During the oxidation process, a certain amount of the organic material is synthesized into new microorganisms. Oxygen is required in the process to support the oxidation and synthesis reactions. Volatile compounds are driven off to varying extents in the aeration process. The process is generally, but not always, preceded by primary sedimentation. The mixture of microorganisms and wastewater formed in the aeration basins, called mixed liquor or activated sludge, is transferred to clarifiers following aeration for liquid-solids separation. The major portion of the microorganisms settling out in the clarifiers is recycled to the aeration basins to be mixed with incoming wastewater, while the excess, which constitutes the waste sludge, is sent to the sludge handling facilities. The rate and concentration of activated sludge returned to the aeration basins determine the mixed liquor suspended solids (MLSS) level developed and maintained in the basins.

All activated sludge processes will be evaluated with the use of selectors. The selector is an anaerobic (or aerobic) zone of initial contact between biomass and influent to provide a competitive advantage for desired microorganisms. These microorganisms assimilate most of readily available organics so that organisms that have good settling characteristics dominate. This enhances non-bulking conditions in secondary clarifiers. Bulking sludge is a major problem at some municipal treatment plants.

3.2 ACTIVATED SLUDGE, OXYGEN

Oxygen activated sludge, like other activated sludge processes, uses suspended microorganisms to remove organics contained in domestic wastewater. The organisms are fed to and contacted with wastewater in continuous flow-through treatment tanks. Pure oxygen, which is normally provided by onsite generation equipment, is diffused into the aeration tanks by mechanical mixing equipment.

Pure oxygen systems are generally enclosed and operated under a slight pressure in an oxygen rich atmosphere. Consequently, the system has a higher dissolved oxygen concentration.

3.3 BURNS-McDONNELL TREATMENT SYSTEM (BMTS)

BMTS is an activated sludge system in which the aeration tank is a racetrack-shaped oxidation ditch and the clarifier is suspended inside the aeration tank. Most of the mixed liquor flows beneath the clarifier, while part of it flows upward into the clarifier. In the clarifier, solids separate from the liquor and fall back into the mixed liquor. The clarified effluent flows into orifice pipes submerged beneath the water surface.

3.4 POWDERED ACTIVATED CARBON

Powdered activated carbon is used in activated sludge systems to adsorb soluble organic materials and to aid in the clarification process. Powdered carbon is fed to the aeration tanks. The spent carbon is removed within the sludge and is disposed of or regenerated.

3.5 DEEP SHAFT

The deep shaft system is an activated sludge process that employs a vertical underground shaft to provide highly efficient oxygen transfer for the biodegradation of wastewater. Biological solids can be separated using either subsequent flotation or sedimentation.

According to the manufacturer, Deep Shaft Technology Inc., the deep shaft bioreactors may vary in depth (300-800 ft) and in diameter (1.5 - 30 ft). A shaft is divided into "downflow" and "riser" sections, and the latter is surmounted by a gas-disengagement tank where gross bubbles of dispersed nitrogen, residual oxygen, and carbon dioxide are released. A portion of the flow from the gas-disengagement tank is fed to a solids separation system, while the remainder is recycled through the shaft.

3.6 SEQUENCING BATCH REACTOR (SBR)

The SBR unit is a method of wastewater treatment that uses the same basin for both biological degradation and solids-liquid separation. By using a single basin design and operation, the need for separate clarifier units and equipment normally associated with such structures (i.e. sludge return lines scrapers) is eliminated.

The basin is operated with an aeration sequence followed by a non-aeration sequence. These two sequences together constitute a cycle. Near the end of the non-aeration sequence, after solid-liquid separation has taken place, effluent, as surface liquor, is removed from the basin until the designated operating bottom water level is reached. The cycle is then repeated. The process operates in the batch mode.

3.7 ROTATING BIOLOGICAL CONTACTORS (RBCS)

RBCs are biological-disc units that consist of a shaft of rotating circular plates immersed approximately 40 percent in a contour bottom tank. The discs are spaced so that during

submergence, wastewater can enter between the surfaces. When rotated out of the tank, air enters the voids while the liquid trickles out over the fixed films of biological growth attached to the media. Excess microbial solids on the media are stripped off by rotational shear forces and the stripped solids are maintained in suspension by the mixing action of the rotating media. Multiple staging of RBCs increase treatment efficiency. The process is similar to trickling filters in that treatment is provided via biological fixed-film attached growth.

3.8 TRICKLING FILTER, PLASTIC MEDIA

The process consists of a fixed bed of plastic media over which wastewater is applied for aerobic biological treatment. Zooglea biological slimes form on the media, which assimilate and oxidize substances in the wastewater. The bed is dosed from the top, and the treated wastewater is collected by an underdrain system.

The organic material present in the wastewater is degraded by a population of microorganisms attached to the filter media. As the microorganisms grow, the thickness of the slime layer increases. Periodically, the liquid will wash some slime off the media, and a new slime layer will start to grow. This phenomenon of losing the slime layer is called sloughing and is primarily a function of the organic and hydraulic loadings on the filter. Filter effluent recirculation is vital with plastic media trickling filters to ensure proper wetting of the media and to promote effective sloughing control compatible with the high organic loadings employed.

3.9 BIOLOGICAL FILTRATION

Biological filtration is a filtering process that relies on suspended aerobic growth on a fixed granular media to reduce organic levels. In the up-flow mode, air injection provides the fixed culture with the necessary oxygen required for the level of BOD removal necessary. The granular media forming the biological growth area also acts in the traditional role, filtering out suspended solids.

One downflow process, patented by Infilco-Degremont, Inc., is known as the Biodrof process. The process is a dry bed downflow filtration process in which the filter and biological growth media are never submerged. The influent is metered onto the media through a series of launders equipped with orifices. Air is drawn into the filter media concurrently by a blower-induced vacuum applied to the media through the underdrain at the level necessary for the biological activity required.

3.10 COUPLED SYSTEM

The coupled system consists of two unit processes (fixed film and activated sludge). The processes that will be evaluated for the MWRA project are the trickling filter and aeration units. The settled solids from the final clarifier are recycled to the head of the aeration basin and mixed with the flow from the fixed film process. A portion of these solids are wasted in order to maintain the desired concentration of MLSS in the aeration basin. The

potential advantages offered by the coupled system are: (1) lower energy usage since a large fraction of the BOD can be removed in the fixed film process; (2) better settling solids from the aeration basin (depending on the operational mode selected) as compared to those in the conventional activated sludge process; and (3) more uniform load on the activated sludge system since the fixed film process reduces peak BOD load.

3.11 PULSED BED FILTRATION

In conventional single-medium sand filters, most of the solids are removed at or near the surface of the sand bed forming a layer of solids. As a result, head loss increases rapidly, filter runs are short, and most of the removal capacity of the filter bed is not utilized. In the pulsed bed filter, intermittent air pulsing of the filter bed is used to loosen and mix the solids retained in the surface layers of the filter, moving this material deeper into the sand bed. The pulse action and the attendant redistribution of solids within the bed decrease the rate of head loss buildup, allowing longer filter runs. Two stage filtration with polymer addition is required to achieve suspended solids removal equivalent to secondary treatment. However, BOD_5 removals equivalent to secondary treatment will not be achieved.

3.12 PHYSICAL-CHEMICAL TREATMENT

Independent physical-chemical treatment utilizes physical-chemical unit processes rather than biological treatment to provide secondary treatment.

A typical process train is as follows:

1. Chemical Mix -- Lime is added to the raw wastewater to reduce the level of suspended organic solids

2. Sludge Blanket Clarifier -- Flocculation and sedimentation of particles

3. Filtration -- Suspended solids and BOD removal

4. Activated Carbon -- Adsorbance of soluble organic materials

3.13 SECONDARY CLARIFIERS, RECTANGULAR

The design of secondary clarifiers is similar to primary clarifiers except that the volume and hydraulic nature of the flocculent solids in the mixed liquor must be considered during the design of activated sludge clarifiers and in the sizing of sludge pumps.

3.14 SECONDARY CLARIFIERS, CIRCULAR

The design of secondary clarifiers is also similar to primary clarifiers except that the volume and hydraulic nature of flocculent solids in the mixed liquor must be considered during the design of activated sludge clarifiers and in the sizing of sludge pumps.

Two types of units exist: the center feed, and the rim feed. Both utilize a revolving mechanism to transport and remove the sludge from the bottom of the clarifier. Circular clarifiers are made with effluent overflow weirs located near the center or near the perimeter of the tank.

3.15 SECONDARY CLARIFICATION (HIGH RATE), FOLLOWED BY FILTRATION OR SCREENING

The clarifiers in a high rate/filtration process are designed at an overflow rate of 800 gal/day/ft^2 compared to a conventional system with an overflow rate of 450 gal/day/ft^2. Under one option, secondary clarification is followed by a filtration process. A typical multimedia filter (55 percent coal, 30 percent sand, 15 percent garnet) loaded at 5 gpm/ft^2 would produce an effluent of less than 10 mg/L. Under a second option secondary clarifiers would be followed by microscreens. Microscreening is a physical straining process normally used to remove suspended solids from secondary effluents for polishing purposes. A typical unit consists of a motor driven rotating drum, covered with a fine screen. The unit is usually mounted horizontally in a rectangular channel. The wastewater enters the drum through one end and passes out through the screen, with the suspended solids being retained on the inner surface of the screen. Pressure jets of plant effluent are directed down onto the screen to remove the deposited solids from the inside of the drum. The wash water must be recycled upstream to the point where the main portion of the solids are removed from the wastewater being treated. Biological growths on the microscreen are controlled by periodic treatment with a chlorine solution. In some cases, placing ultraviolet lights above the screen medium has been effective in controlling growths.

3.16 TRAY CLARIFIERS

Tray clarifier units are similar to conventional rectangular clarifiers with the following differences. The units are stacked with wastewater entering the lower unit and traveling to the upper. No pumps are needed to lift the flow. Sludge is captured at the lower portion of each unit and is gravity fed to a hopper and to further sludge processing.

3.17 STACKED CLARIFIERS

Stacked clarifier units are similar to conventional rectangular units except that two clarifier units are constructed over one another. This saves approximately 40 percent of the total area required for conventional rectangular clarifiers. Stacked clarifiers, unlike the tray-type units, have separate wastewater influent distribution and effluent collection facilities. Each stacked clarifier can be operated independently of the other. Sludge is captured at the lower portion of each unit and is gravity fed to a hopper for further sludge processing.

3.18 ROTARY SCREEN

A rotary screen is a horizontal or rotating drum covered with a plastic or stainless steel screen of uniformly sized openings, installed and partially submerged in a chamber. The chamber is designed to permit the entry of wastewater to the interior of the drum and

collection of screened wastewater from the exterior side of the drum. With each revolution, the solids are flushed by sprays from the exposed screen. Rotary screens have been used for further treatment of primary or secondary effluent.

4.0 DISINFECTION

4.1 LIQUID CHLORINE

Liquid chlorine is the benchmark against which other disinfection methods have historically been evaluated. Liquid chlorine is gaseous chlorine that has been compressed to a liquid state for ease of transportation and handling. It is converted back to the gaseous state at the point of application and injected into the wastewater to be disinfected. The standards for duration and intensity of disinfection have been set based upon the use of chlorine or one of the related chloride compounds, the most common being sodium hypochlorite.

Liquid chlorine can be toxic to humans if inhaled as a gas, and thus the transportation, handling, and storage of this product must be done in strict accordance with regulations to eliminate the potential risk of spillage. For the Deer Island site, the liquid chlorine risk issue was evaluated during the site selection impact studies. The Federal Environmental Impact Statement (EIS) included the following as a condition for the Deer Island site:

"...as a mandatory mitigation measure, if Deer Island is to be the site of the new treatment plant, liquid chlorine shall not be used at a new Deer Island treatment plant unless the MWRA can demonstrate to EPA during facilities planning that there is a clear and convincing need for the use of liquid chlorine and that it can be transported, handled, stored, and used in an environmentally acceptable manner."

This statement along with the associated text has been interpreted to mean that liquid chlorine will not be used unless there are no alternatives to the use of liquid chlorine. Therefore, since options utilizing sodium hypochlorite are feasable, liquid chlorine has been eliminated from further consideration.

4.2 SODIUM HYPOCHLORITE

Sodium hypochlorite is applied as an aqueous solution. It can be commercially purchased in varying strengths. At wastewater treatment facilities it is typically purchased as a 15 percent solution by weight. At this strength one gallon of solution has approximately one pound of chlorine available in solution. Higher strengths can be purchased but the solution is unstable and will decrease in strength while in transit and storage. Weaker solutions can also be purchased, the most common being household bleach.

Sodium hypochlorite is dosed into the effluent and then held in contact for a specified period after which the residual chlorine level is measured as a means of evaluating disinfection efficiency. In Massachusetts the DEQE/DWPC relies upon the New England Interstate Standards for establishment of contact times. Those regulations require a 15-minute contact time at peak flow unless the discharge is to shellfish areas, in which case the contact time will be 30 minutes. It is assumed for area sizing that a 15-minute contact time is appropriate. The area required for contact would be approximately 2 acres. No allowance has been made for the time of travel within the outfall.

The supply of sodium hypochlorite to the Deer Island treatment facility would be accomplished by one of three methods:

1. Trucking of sodium hypochlorite solution
2. Barging of sodium hypochlorite solution
3. Onsite manufacture of sodium hypochorite solution

Method 1 would involve a number of tank trucks travelling to and from the site either overland, or via a roll-on roll-off barge. Storage facilities would be necessary on the site. The sodium hypochlorite most likely would be manufactured by local chemical suppliers from liquid chlorine at existing or expanded production facilities. The trucking of sodium hypochlorite is commonly done, while the use of roll-on roll-off barges for transport is not known to be done as such; however, containers of sodium hypochlorite are transported on ships. Local harbormaster approval and Coast Guard concurrence will be required.

Method 2 would involve the purchase or lease of a bulk barge and customizing the barge, most likely to a double hull configuration, to protect against spills and the corrosive nature of the sodium hypochlorite. At present there are presently no known facilities for on-loading of barges. There is the potential for such facilities in areas such as Providence, Rhode Island, or Portsmouth, New Hampshire. The development of such facilities would require a long-term commitment from MWRA to a local chemical supplier to justify the necessary capital investment. Additionally, approvals would be necessary from both the local harbor master as well as the Coast Guard. The travel time for such bulk barge deliveries would require that on-site storage be provided to guard against interruptions due to inclement weather. It is assumed that a minimum of five days reserve should be maintained at all times. The area needed for storage would be approximately 1 acre.

Method 3 would involve the on-site generation of sodium hypochlorite by electrolitic methods. Such systems are commercially available units and have been used at varying facilities ranging from off-shore oil platforms, nuclear power plants, and wastewater treatment facilities. The systems are modular in nature and can theoretically be constructed to produce sufficient quantities of sodium hypoclorite for the proposed site. The systems require significant amounts of power. They must be routinely maintenanced by means of acid cleaning and replacement of the sacrificial anode/cathode every 3 to 5 years. The required area is less than an acre, not including storage for peak demand. The strength of the solution produced is relatively weak.

4.3 OZONE

Ozone has been used as a disinfectant for drinking water for a number of years in Europe and has recently become quite common in this country. Its use for the disinfection of secondary effluent wastewater is not very common. It has been used for disinfection of tertiary wastewaters and for specific chemical wastewater polishing -- most notably with cyanide wastes.

Ozone can be produced from either air or oxygen. Both systems require significant amounts of electricity for their operation. The systems also produce noise, particularly the oxygen

system compressors. The contact time required is minimal -- three to five minutes. Measurement of ozone's effectiveness is difficult and therefore requires that overdosage be practiced. There is believed to be no negative impact upon the receiving waters based upon information available to date.

4.4 ULTRAVIOLET IRRADIATION

Ultraviolet irradiation as a means of disinfection was essentially nonexistent 15 years ago. The EPA's I/A program led to the rapid development of ultraviolet irradiation as an acceptable method of disinfection. The system's effectiveness is dependent upon the transmissivity of the effluent, and the strength and duration of the UV dosage applied. Practically, this has meant that the UV source, which resembles a florescent lamp, must be placed within 1 to 3 inches of the bacteria to be destroyed. There are presently two principal types of systems: one in which the effluent is passed in trays below the UV source, and one in which banks of UV tubes are immersed within a channel with effluent flowing around them. The first type of system is most appropriate for very low flow plants (less than 1 mgd).

There is limited literature available to accurately predict the effectiveness of UV on a primary effluent. Tests of UV for disinfection of CSO wastewater have been conducted. The strength of the CSO in the test was greater than the average influent to the proposed STF plant. The UV disinfected the CSO to values of 1200 to 1600 MPN/100 ml fecal coliform. Further analysis is necessary to predict the effectiveness of UV on the proposed primary effluent.

An in-channel UV system would require that multiple channels be available. There is no easy method for determining the effectiveness of the disinfection; therefore, overdosage would have to be practiced. There is no evidence of negative impact upon the receiving waters. The required detention times are quite short -- four to six minutes.

Secondary Treatment Facilities Plan

Volume III

Appendix D
Noise and Sound Data, Point Shirley

1.0 INTRODUCTION

Noise associated with the construction and operation of the new Deer Island Wastewater Treatment Facilities has the potential for creating a noise impact on portions of the Town of Winthrop, particularly in the Point Shirley area, adjacent to Deer Island and at Quincy Great Hill, adjacent to Nut Island. To minimize the noise impact, noise control requirements have been incorporated into the treatment facilities planning process through the use of noise evaluation criteria. These criteria have been employed in judging the effectiveness and acceptability of noise controlling alternatives as they apply to selection of wastewater treatment equipment, site planning, and construction.

This report describes the development of the noise evaluation criteria, considerations given to the noise prediction methodology, evaluation of noise control requirements for alternative treatment facility processes, predictions of construction noise and noise from the recommended facility operation, and recommendations for implementing a noise control plan.

2.0 SELECTION OF NOISE IMPACT ASSESSMENT CRITERIA

2.1 INTRODUCTION

Noise impact assessments usually rely on baseline noise levels for judging the magnitude and acceptability of incremental noise changes. Several brief baseline noise surveys were previously made within the Point Shirley study area relating to multiple site assessments and specialized projects. These were reported in Supplemental Draft Environmental Impact Statement on Siting Of Wastewater Treatment Facilities For Boston Harbor, 1986; Thibault/Bubly Associates, 1986; MWRA, Notice of Project Change, July 1986; Final EIR On Siting Of Waste Water Treatment Facilities For Boston Harbor, 1985. These surveys sampled ambient noise for periods of a few minutes up 24 hours. A more extensive study was required for this analysis to provide a firm statistical basis for the development of recommended noise criteria for Deer Island. The results of this survey, and recommendations for construction and operational noise criteria are summarized herein.

2.2 REGULATIONS AND GUIDELINES

The assessment of noise impact involves determining both the increase in ambient noise and compliance with appropriate regulations. Three noise regulations are potentially applicable to the site and are summarized as follows:

The City of Boston Noise Regulations address various sources of noise and set specific noise limits for the transmission of sound between properties of the same and different zoning. The allowable noise level transmitted to a residential zone during the daytime hours of 0700 to 1800 is 60 dBA. A 50 dBA level is allowable during the remaining nighttime hours. The maximum allowable noise level allowed to be transmitted to an industrial site is 70 dBA. The code also

has corresponding octave band level requirements.

The Boston noise code limits construction noise at the residential and institutional property lines to an L10 level (the level exceeded 10% of the time) of 75 dBA and a maximum level of 86 dBA. The allowable L10 for recreational land is 80 dBA. Construction is not permitted at night or on weekends unless the construction noise level at the residential property line does not exceed 50 dBA.

The State of Massachusetts Department of Environmental Quality (DEQE) guidelines on noise allow a new facility to increase the ambient noise a maximum of 10 dBA over the existing L90 ambient noise. The L90 levels are the lowest values measured at night. The measurements of the ambient sound level and the resulting DEQE requirements are discussed in later sections of this report. The DEQE guidelines also prohibit the emission of a pure tone from noise sources. A pure tone is defined as occurring when the level in one octave band exceeds the level in the two adjacent octave bands by 3 dB or more.

All equipment on the site will be required to conform to the U.S. Department of Labor's Occupational Safety and Health (0SHA) requirements on noise exposure. These regulations allow an equivalent 8-hour exposure of 90 dBA for the protection of employee hearing. Where equipment cannot be purchased to meet OSHA noise exposure requirements, noise mitigation will be added as required.

2.3 AMBIENT SOUND LEVEL SURVEY

For this report an ambient sound level survey was conducted at Point Shirley, in the Town of Winthrop, in the nearest areas potentially impacted by facility construction and operation noise. The goals of the survey were the following:

1) Establish the spatial variation in the ambient sound levels throughout Point Shirley.

2) Establish the diurnal (day vs night) variation in the sound levels.

3) Determine the temporal variability of sound levels from day to day.

4) Identify the sources of noise controlling the ambient levels.

2.3.1 MEASUREMENT LOCATIONS

A preliminary inspection of the study area indicated that the primary noise sources were Logan Airport, traffic on Tafts Avenue and other local roads, surf noise from the beaches, and, occasionally, the existing treatment plant. Previous studies indicated that the Nordburg diesel drives on the existing wastewater pumps were sometimes audible.

The prior noise surveys also assessed the sound levels throughout Winthrop and concluded that the mainland portion of Winthrop had nighttime L90 levels in the 34-40 dBA range, whereas Point

Shirley was slightly louder, in the 40-43 dBA range. However, because of the much greater distance to the other parts of Winthrop, criteria selected for Point Shirley will serve as a conservative criteria for the balance of Winthrop.

Noise measurement locations were selected to provide data on each of the sources discussed above to be spatially distributed across Point Shirley. A map of the locations is given in Figure D-1. All of the locations except No.1 have line-of-sight shielding by houses from the airport and surf. Location 1 was shielded by a house from the diesel pump station noise. Locations 2 and 3 had line-of-site visibility to the diesel pump station.

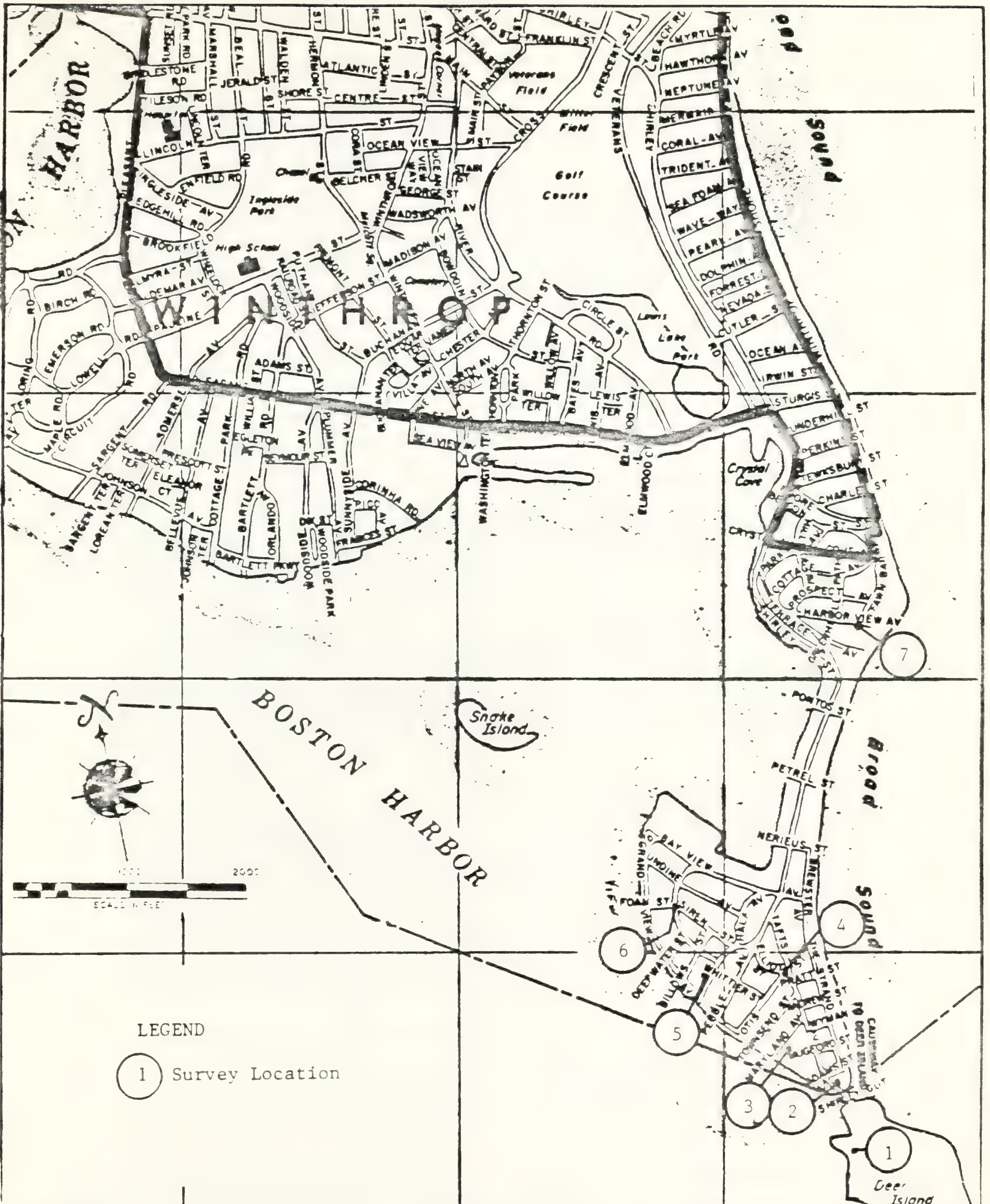
Two types of noise survey methodologies were used in conjunction with each other to provide a complete description of the spatial and temporal variation in sound levels. The first type consisted of the continuous monitoring of sound levels sequentially at locations 1 and 3, shown in Figure D-1, for 17 days. Locations close to the plant were selected for the continuous monitoring of the existing sound levels because the potential for adverse noise impact is the greatest there. The monitor was periodically calibrated throughout the survey. Continuous monitoring allowed the collection of a more extensive data base than is possible with staffed surveys.

The second type of survey was staffed, and measurements were taken with portable instrumentation. During these surveys 10-minute statistical samples of sound levels were taken, and on 3 out of 5 of the surveys, residual octave band measurements were also taken. The staffed surveys enabled a number of locations to be measured and the sources of noise noted. The staffed surveys were conducted during 2 to 3 hour periods during the day and nighttime hours at locations 1, 2, 4, 5, 6, and 7.

2.3.2 INSTRUMENTATION

A Larson Davis 800 Noise Analyzer and a Bruel and Kjaer 2215 sound level meter were used manually to measure the residual octave band sound pressure levels and A-weighted sound level statistics. The residual octave band measurements were taken in the absence of transient noise such as passing vehicles and aircraft landings. Ten-minute statistical samples of the A-Weighted sound level were taken by reading the meter every 10 seconds and preparing a histogram of the data. All measurements were taken with local winds at less than 10 mph.

A Larson-Davis 700 Noise Dosimeter was used to continuously measure and statistically analyse the variable ambient noise. The device was programmed to provide hourly statistics including the L10, L50 and L90 values, that is, the level exceeded 10%, 50% and 90% of the time. The L90 value typically represents the residual, or background level which occurs when transient noise is absent.



MASSACHUSETTS WATER RESOURCES AUTHORITY

FIGURE D-1
AMBIENT SOUND LEVEL SURVEY
MEASUREMENT POSITIONS, WINTHROP, MASSACHUSETTS, SEPTEMBER 1986

2.4 SURVEY RESULTS AND DISCUSSION

2.4.1 MANUALLY COLLECTED DATA

The manually collected data discussed above is presented in Tables D-1 through D-5. Most of the L90 sound level data taken at some distance from the water (locations 4, 5, and 6) were in the 42-47 dBA range. Measurements taken from locations, which are more exposed to surf noise (locations 1, 2, 3, and 7), were sometimes several decibels higher.

During the day and evening hours the intervals of time between aircraft takeoff and landing noise were observed to be infrequent and brief. However, after the hours of approximately 2300 to 2400, takeoffs and landings became infrequent and the residual levels appeared to be controlled by surface aircraft operations at Logan Airport, surf noise, and occasionally the Nordburg diesel drives of the waste treatment pumps on Deer Island.

In general, the more sheltered locations, i.e., those away from the shore, were 5 to 6 dBA quieter than those near the water because these locations were partially shielded by houses from Logan ground operations, surf, and occasionally diesel noise. This was also observed in the field by measuring the noise primarily from surface aircraft operations, first from behind a house and then with line-of-sight to the airport.

The pump station diesels were inaudible at all locations when the winds were northerly. This is because the vertical gradient in wind speed tends to raise the upwind sound wave off the ground and creates an acoustical shadow zone. However, when the winds had a southerly component, i.e., from the direction of the diesels, the diesels were, on occasion, audible at one or two measurement locations which varied from survey to survey. Diesel audibility is indicated in Tables D-1 to D-5.

When audible, the diesel sound varied in an irregular, pulsing manner, caused by multiple diesel units operating at slightly different speeds. Most of the diesel noise was in the 63 Hz octave band, corresponding to the cylinder firing rate. At one of the measurement locations, the diesels caused a 4-dBA variation in the sound level when measured with the sound level meter on "fast" response. The level in the 63 Hz band on "fast" response varied from 5 to 10 dB. On "fast" response the meter's response time is reduced and the meter becomes very sensitive to rapid changes in sound level. All other measurements were taken on "slow" response, as is standard practice for community noise measurements.

2.4.2 CONTINUOUS MONITOR DATA

A tabulation of the data from the continuous monitor first used at Location 1 and then at 3 is given in Attachment D-1. This data describes the diurnal variation in sound level for 13 days at Location 1 and five days at Location 3.

The L90 data were divided into meaningful time periods and sorted to examine the group

TABLE D-1

AMBIENT SOUND PRESSURE LEVELS, September 3, 1986, Winthrop, MA

MEASUREMENT LOCATION (TIME OF SURVEY)	L90 dBA	RESIDUAL OCTAVE BAND CENTER FREQUENCY, HZ								
		31	63	125	250	500	1000	2000	4000	8000
1. Engineers House		Not Collected								
2. 150 Tafts (1300-1310)	45	Not Collected								
4. Tafts & Otis (1337-1347)	43	Not Collected								
5. Shirley & Triton (1450-1500)	44	Not Collected								
6. Siren & Triton (1414-1424)	40	Not Collected								
7. Harbor View (1500-1510)	42	Not Collected								

NOTE:

Weather conditions: Wind E, < 5 mph, overcast.

TABLE D-2

AMBIENT SOUND PRESSURE LEVELS, September 5, 1986, Winthrop, MA

MEASUREMENT LOCATION (TIME OF SURVEY)	L90 dBA	RESIDUAL OCTAVE BAND CENTER FREQUENCY, HZ 31	63	125	250	500	1000	2000	4000	8000
1. Engineers House	Not Collected									
2. 150 Tafts (1000-1015)	51	58	60[1]	63	53	42	37	33	28	25
4. Tafts & Otis (1037-1047)	43	55	55	50	41	38	38	30	30	17
5. Shirley & Triton (1053-1104)	42	55	58	51	49	45	40	32	27	20
6. Siren & Triton (1115-1126)	44	57	57	53	45	38	35	29	29	21
7. Harbor View (1139-1152)	49	61	60[2]	57	49	44	41	37	32	32

NOTE:

[1] Diesels just audible, pulses to 70 dB.
[2] Diesels audible, pulses to 65 dB.
Weather conditions: Wind Light, Southerly, Sky Clear.

TABLE D-3

AMBIENT SOUND PRESSURE LEVELS,
September 16, 1986, Winthrop, MA

MEASUREMENT LOCATION (TIME OF SURVEY)	L90 dBA	RESIDUAL OCTAVE BAND CENTER FREQUENCY, HZ 31	63	125	250	500	1000	2000	4000	8000
1. Engineers House	53	60	65	60	56	56	49	44	38	27
2. 150 Tafts (2200-2210)	48	Not Collected								
4. Tafts & Otis (2300-2310)	47	Not Collected								
5. Shirley & Triton (2420-2430)	46	Not Collected								
6. Siren & Triton (2339-2349)	46	Not Collected								
7. Harbor View (2358-0008)	48	Not Collected								

NOTE:

Weather conditions: Winds N at 5 mph.

TABLE D-4

AMBIENT SOUND PRESSURE LEVELS,
September 17-18, 1986, Winthrop, MA

Measurement Location (Time of Survey)	L90 dBA	RESIDUAL OCTAVE BAND CENTER FREQUENCY, HZ 31	63	125	250	500	1000	2000	4000	8000
1. Engineers House	47	60	65	56	51	43	40	27	33	19
2. 150 Tafts (0010-0024)	40	55	60[1]	53	42	35	29	22	18	15
4. Tafts & Otis (2355-0005)	38	51	52	49	41	36	29	22	15	14
5. Shirley & Triton (2338-2350)	42	55	55	56	49	39	34	26	22	15
6. Siren & Triton (2322-2333)	47	57	57	52	50	46	39	28	25	16
7. Harbor View (2304-2314)	48	53	61	52	45	41	38	38	32	20

NOTE:

[1] Diesels audible, level varies to 70 dB with pulses.
Weather conditions: Wind SW Light to calm.

TABLE D-5

AMBIENT SOUND PRESSURE LEVELS,
September 18-19, 1986, Winthrop, MA

MEASUREMENT LOCATION (TIME OF SURVEY)	L90 dBA	RESIDUAL OCTAVE BAND CENTER FREQUENCY, HZ 31	63	125	250	500	1000	2000	4000	8000
1. Engineers House (0025-0036)	48	60	65[1]	57	47	42	37	32	28	18
2. 150 Tafts (2335-2345	46	57	60[1]	54	46	40	36	32	28	23
4. Tafts & Otis (2314-2325)	42	56	58[2]	55	44	38	34	27	26	18
5. Shirley & Triton (2242-2252)	44	57	57	55	45	40	36	32	30	23
6. Siren & Triton (2250-2309)	43	56	59	51	45	40	34	28	20	22
7. Harbor View (2216-2227)	50	55	60	55	46	45	40	36	35	32

NOTE:

[1] Diesel audible, 70 dB peak.
[2] Perhaps, just audible.
Weather conditions: Winds SW, very light.

statistics. The L90 sound levels for the nighttime period of 2300 to 0600 were grouped together and sorted to determine their percentiles of exceedence. During this period of time it is likely that a significant percentage of the population would be sleeping.

This analysis indicates that 50 percent of the nighttime L90 values were greater than 45 dBA, indicating that 45 dBA is a typical value for the nighttime L90 sound level. The 90 percentile value of the L90 sound level was 39 dBA. Thus, for most hours, the L90 sound level at that location exceeds 39 dB. The lowest hourly L90 value measured was 35 dBA at location 1.

A similar analysis was performed for the daytime hours of 0700 to 1800. It is not yet known what the specific hours of construction will be, but this time period includes the most common periods of construction. The quietest hour during this period was 41 dBA. However, 90 percent of the time the L90 levels were in excess of 45 dBA, and 50 percent of the time they exceeded 51 dBA. These data are summarized in Table D-6. These measurements generally agree with the previous shorter-term assessments on noise at Point Shirley referenced in Section 2.0.

2.5 RECOMMENDED CRITERIA

Two noise assessment criteria are required: one for assessing the noise from daytime activities such as construction and operation of the facility; and one for assessing the nighttime operation of the facility. These criteria differ because the ambient sound level and household activities change from day to night.

Criteria selection involves choosing the lowest ambient sound level likely to occur, because it is at this time that any new intrusive noise will be the most obvious and have the greatest impact. Obviously, the longer the ambient sound levels are sampled, the more likely an even lower value will be measured.

The analysis discussed in Section 2.4.2 indicates that the nighttime hourly ambient L90 sound level is greater than 39 dBA 90 percent of the time; therefore it is recommended that 39 dBA be used to assess the maximum nighttime noise impact at the property line. Other portions of Winthrop are much further away from Deer Island and will receive adequate protection with the same criterion. This results in a DEQE requirement of 49 dBA for the allowable 10 dBA above ambient stipulated in the Massachusetts DEQE Regulation 10 of the Air Pollution Regulations. It is not recommended here that a 49 dBA level is the design goal, but rather a legal requirement which the site operational noise must, and will, meet.

In a similar manner, the criterion for assessing daytime noise impact was determined to be 45 dBA. Construction planning will address the timing of construction activities. Since the lowest ambient noise levels occur during the middle of the day and the middle of the night, the maximum impact assessment criteria remain essentially the same during the evening as during the day.

A summary of the noise impact assessment criteria are shown in Table D-6 for both daytime and nighttime impact assessment. These criteria are recommended to be used as the ambient basis

TABLE D-6

SUMMARY OF NOISE ASSESSMENT CRITERIA, dBA
POINT SHIRLEY, TOWN OF WINTHROP

	L90
Daytime 0700-1800	45
Nighttime 2300-0600	39
DEQE nighttime operation noise limit, no pure tone	45
DEQE daytime operation noise limit, no pure tone	51
OSHA on-site 8 hour exposure limit	90

for assessing the impact of construction and operation noise, determining acceptable noise control techniques, and determining noise mitigation measures.

In summary, the ambient (L90) for assessing maximum nighttime and daytime noise impact in the Point Shirley area are 39 and 45 dBA, respectively. Predicted construction and operation noise levels will be compared with these levels in future analyses to determine the need and amount noise mitigation. The DEQE level not to be exceeded for a constant nighttime operation noise was determined to be 49 dBA.

3.0 FACTORS AFFECTING SOUND PROPAGATION

3.1 INTRODUCTION

During the course of making noise predictions for construction and operation of the facility, assumptions must be made regarding several factors which affect the noise propagation calculations, namely atmospheric absorption, anomalous attenuation, and barrier attenuation. This section discusses the selection of these factors and methodologies which have been used for the project.

3.2 SELECTION OF ATMOSPHERIC ABSORPTION COEFFICIENTS

3.2.1 INTRODUCTION

This section describes the methodology used to select site specific Minimum Atmospheric Absorption Coefficients (MAACs) which will be used for predicting noise impact from the construction and operation of the Deer Island Wastewater Treatment Facility. The MAAC defines the absorption of sound by the atmosphere in decibels per 100 meters for all temperature and humidity combinations, and vary by a factor of approximately four from their highest to lowest values for a given audio frequency. Often the MAACs for typical conditions of 15 degrees C and 70% relative humidity are used for this purpose, but in an effort to make the noise predictions conservative, site specific MAACs were developed from the applicable American National Standards Institute (ANSI) standard, utilizing the specific sound frequencies of concern, and a statistical analysis of five years of weather data recorded at Logan International Airport.

Atmospheric absorption of noise is a complex function of temperature and humidity. The higher the frequency, the greater the atmospheric absorption. However, there is no single set of meteorological conditions which gives minimum absorption at all frequencies. The conditions which give minimum absorption for one frequency give maximum absorption at another, etc. Thus, the MAACs must be examined in detail to select the appropriate conditions for the frequencies being studied.

3.2.2 APPROACH

The purpose of this analysis was to identify the MAACs that will occur at the site. Briefly,

the approach used was to 1) identify the MAAC for each temperature range, 2) determine which octave band frequencies are the ones of primary importance for noise propagation, 3) choose the weather conditions which give minimum absorption for the octave bands of concern, and 4) evaluate the frequency of occurrence of the weather conditions which produce the lowest MAACs. Absorption coefficients were selected from the ANSI standard entitled, "Method for the Calculation of the Absorption of Sound by the Atmosphere" (ANSI S1.26-1978). The approach is described below:

1. Identify MAACs

1a. Using the atmospheric absorption coefficient table of the standard, (Attachment D-2) for each temperature classification (0, 5.0, 10.0 degrees C, etc.), the lowest value of the AAC was underlined for each of the octave band center frequencies, as shown in the Attachment.

2. Determine significant octave band frequencies

2a. A curve was plotted for each octave band center frequency of MAAC vs. temperature as shown in Figure D-2

2b. The variation of sound absorption at 800 m from the site was determined as the MAAC ranged from its lowest to its highest value. This was determined by multiplying the MAAC by 8 (for 800 meters) and dividing by 2 to get the range. (MAAC x 8 m/2). 800 m was used as a typical distance from power generation facilities on the site to the nearest neighbor. This number, shown in Table D-7 illustrates the sensitivity of the far-field sound level to variations in the MAAC.

From the table it is determined that at 125 hz, the range in MAACs will cause a variation of $\pm$ 0.08 dB in the sound level at 800 m. Likewise the variability at 250 and 500 Hz is $\pm$0.2 and $\pm$0.4 dB respectively. It can be seen that the variability at 125 and 250 Hz is so small that the weather dependance of the MAAC can be ignored.

2c. It may be further observed that frequencies of 4000 Hz and higher are of no concern because they are attenuated so much with distance that they have no impact on the sound level. For instance, at 800 m the 4000 Hz MAAC gives 22 dB more attenuation than at 2000 Hz. In addition, construction and operation noise is usually very low at 4000 Hz. Thus high frequency noise is not generally of concern for construction and operation noise.

3. Select Meteorological Conditions

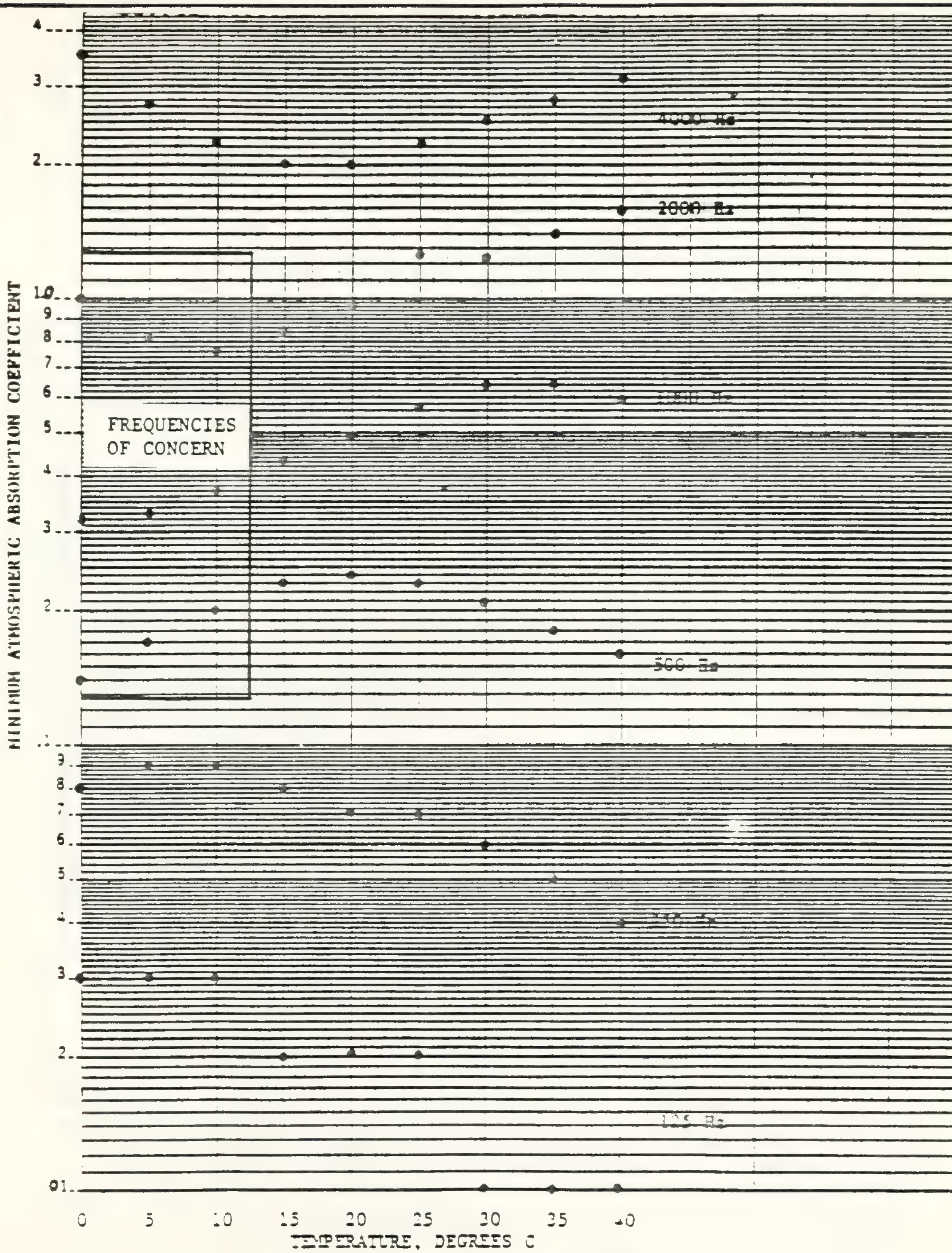
It has been demonstrated in steps 2b and 2c that only the 500, 1000, and 2000 Hz octave bands need be considered in selecting meteorological conditions giving minimum MAACs.

It can be observed from that portion of the curves within the box of Figure D-2 that the

TABLE D-7

VARIABILITY OF SOUND ABSORPTION AT 800 M AS THE MINIMUM ATMOSPHERIC ABSORPTION COEFFICIENT (MAAC) RANGES FROM ITS LOWEST TO HIGHEST VALUE

OCTAVE BAND CENTER FREQUENCIES							
63	125	250	500	1000	2000	4000	8000
-	±0.1	±0.2	±0.4	±1.2	±3.2	±6.0	-



MASSACHUSETTS WATER RESOURCES AUTHORITY	FIGURE D-2 MINIMUM ATMOSPHERIC ABSORPTION COEFFICIENTS VS. TEMPERATURE FOR EACH FREQUENCY

500, 1000, and 2000 Hz MAACs occur at 0 degree, 0 degree, and 10 degree C, respectively. The 0 degree C meteorological condition was selected as the design basis because it has the lowest MAACs for 2 of the 3 curves within the box. As can be seen from Attachment D-2, for 0 degree C., the lowest MAAC is at 100% Relative Humidity (RH).

4. Frequency of Meteorological Conditions

A statistical sort was then performed on five years of weather data from Logan International Airport as shown in Table D-8. It can be seen that the conditions of 0 degrees C and 100% RH which give the MAAC occur 1.9% of the time, i.e., 14 hours per month average for the six winter months where this condition is likely to occur. The design basis MAACs selected were therefore the ANSI values for 0 degree C_g 100 percent RH as given in Table D-9.

3.2.3 Conclusion

The minimum atmospheric absorption coefficients which will give the maximum sound levels in the community have been identified based on site weather conditions. These values are conservative, and most of the sound levels will be lower than predicted. In contrast, the greatest atmospheric absorption coefficient which occurs with any significant frequency, for instance at 1000 Hz, is that for 0 degrees C, 30% RH, which is 1.08 dB/100 m. This provides an additional 6 dB absorption in 800 meters over the MAAC. This means that when maximum absorption is occurring at 1000 Hz the 800 m, 1000 Hz sound levels will be 6 dB lower.

3.3 ANOMALOUS ATTENUATION

The term anomalous attenuation is generally used to describe attenuation caused by factors other than atmospheric absorption, vegetation, and barriers. Values are sometimes presented in decibels per 100 m in the same manner as atmospheric absorption. There is, at this time, however, no general consensus as to what these values should be, or whether or not they should be used.

For instance Kurze and Beranek (1971) evaluated extensive field data collected near Leningrad over a several year period and came up with a design guide for including this factor in propagation calculations. More conservative values are included in a design guide prepared by Miller, et.al.(1978). The use of this factor is not uncommon in engineering calculations.

However, in a recent summary of outdoor noise propagation schemes, Embleton (1982), indicates that during night time downwind noise propagation, the measured absorption can be accounted for solely with distance and atmospheric absorption corrections. This is because temperature inversions cause sound to be refracted downward, and the attenuation provided by ground effects is eliminated. The data presented therein by Parkin and Scholes (1965) confirmed this postulate.

TABLE D-8

DISTRIBUTION OF RELATIVE HUMIDITY VERSUS DRY BULB TEMPERATURE
LOGAN AIRPORT, BOSTON, MA (1970 - 1974)

Dry Bulb Temperature (Degrees)F	Relative Humidity (Percent) 0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-90	91-100	Total	Temperature Degrees C
0 - 26	0	21	292	680	920	821	418	443	95	3690	
Pct Class	0.0	0.57	7.91	18.43	24.93	22.25	11.33	12.01	2.57	100.0	
Pct Total	0.0	0.05	0.67	1.55	2.10	1.87	0.95	1.01	0.22	8.42	
27 - 36	0	38	182	634	1183	1311	897	1487	836	6568	0
Pct Class	0.0	0.58	2.77	9.65	18.01	19.96	13.66	22.64	12.73	100.00	
Pct Total	0.0	0.09	0.42	1.45	2.70	2.99	2.05	3.39	1.91	14.99	
37 - 45	2	21	254	562	1025	1176	1473	2364	663	7540	5
Pct Class	0.03	0.28	3.37	7.45	13.59	15.60	19.54	31.35	8.79	100.00	
Pct Total	0.00	0.05	0.58	1.28	2.34	2.68	3.36	5.40	1.51	17.21	
46 - 54	0	62	251	506	802	1020	1045	2112	977	6775	10
Pct Class	0.0	0.92	3.70	7.47	11.84	15.06	15.42	31.17	14.42	100.00	
Pct Total	0.0	0.14	0.57	1.15	1.83	2.33	2.30	4.82	2.23	15.46	
55 - 63	0	55	161	368	600	875	1000	2551	1154	6764	15
Pct Class	0.0	0.81	2.38	5.44	8.87	12.94	14.78	37.71	17.06	100.00	
Pct Total	0.0	0.13	0.37	0.84	1.37	2.00	2.28	5.82	2.63	15.44	
64 - 72	0	55	214	418	624	937	1388	2940	611	7187	20
Pct Class	0.0	0.77	2.98	5.82	8.68	13.04	19.31	40.91	8.50	100.00	
Pct Total	0.0	0.13	0.49	0.95	1.42	2.14	3.17	6.71	1.39	16.40	

TABLE D-8

DISTRIBUTION OF RELATIVE HUMIDITY VERSUS DRY BULB TEMPERATURE LOGAN AIRPORT, BOSTON, MA (1970 - 1974)

Dry Bulb Temperature (Degrees)F	Relative Humidity (Percent) 0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-90	91-100	Total	Temperature Degrees C
73 - 81	0	22	134	415	751	824	918	876	9	3949	25
Pct Class	0.0	0.56	3.39	10.51	19.02	20.87	23.25	22.18	0.23	100.0	
Pct Total	0.0	0.05	0.31	0.95	1.71	1.88	2.10	2.00	0.02	9.01	
82 - 90	0	6	114	343	367	324	62	1	0	1217	30
Pct Class	0.0	0.49	9.37	28.18	30.16	26.62	5.09	0.08	0.0	100.0	
Pct Total	0.0	0.01	0.26	0.78	0.84	0.74	0.14	0.00	0.0	2.78	
91 - 99	0	1	11	71	43	0	0	0	0	126	35
Pct Class	0.0	0.79	8.73	56.35	34.13	0.0	0.0	0.0	0.0	100.00	
Pct Total	0.0	0.00	0.03	0.16	0.10	0.0	0.0	0.0	0.0	0.29	
100 - 108	0	0	0	0	0	0	0	0	0	0	40
Pct Class	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Pct Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total	2	281	1613	3997	6315	7288	7201	12774	4345	43816	
Pct Class	0.00	0.64	3.68	9.12	14.41	16.63	16.43	29.15	9.92	100.00	
Pct Total	0.00	0.64	3.68	9.12	14.41	16.63	16.43	29.15	9.92	100.00	

TABLE D-9

MINIMUM ATMOSPHERIC ABSORPTION COEFFICIENTS (MAACS) FOR USE IN PREDICTING MAXIMUM NOISE IMPACT FROM THE CONSTRUCTION AND OPERATION OF THE WASTE WATER TREATMENT FACILITY AT DEER ISLAND, dB/100m

OCTAVE BAND CENTER FREQUENCY							
63	125	250	500	1000	2000	4000	8000
.01	.03	.08	.14	.32	.99	3.52	12.13

As per ANSI S1.26 - 1978, 0°C, 100% RH

Because of the lack of a general consensus on this subject, it is proposed that factors for anomalous attenuation not be included in the noise predictions for this project. This will provide conservative, worst case noise predictions.

3.4 BARRIER ATTENUATION

A number of barrier attenuation calculation methodologies have been proposed and discussed in the literature over a period of several decades. Summaries of barrier methodology include those given by Kurze (1974) and Gill (1980). Perhaps the most widely used and simple approach is that developed by Maekawa (1971) and presented in various forms by other investigators. This approach is used by Kurze and Beranek in Beranek's "Noise and Vibration Control" (1971) and by Piercy and Embleton in Harris' "Handbook on Noise Control" (1979). Gill (1980) evaluated the Maekawa methodology as well as other methods in his testing of barriers for mitigating construction noise and found it agreed very well with field tests.

Recently Kurze and Schreiber (1986) developed an additional correction to the Maekawa approach, which accounts for the degradation of barrier attenuation at distances beyond several hundred yards. It is proposed that the Maekawa formula and the Kurze correction term for weather effects be used to calculate a conservative, downwind barrier attenuation on this project.

The resulting formula is:

$$A = 10 \text{ Log } (3 + 20 \text{ w/z} \times K)$$

where:

A = barrier attenuation
w = wave length of sound
z = path difference between straight line, barrier to receiver, and over the barrier
K = weather constant

4.0 ALTERNATIVE ANALYSIS

The purpose of this analysis was to evaluate the off-site noise for each alternative task or process in order to categorize the noise control engineering effort required as minimal, modest, or difficult. This evaluation was performed by estimating the sound level of each alternative at the nearest residence, approximately 2200 ft north on Tafts Avenue on Point Shirley. A preliminary judgement was then made as to the relative impact of the noise, and, where the predicted sound levels were significantly higher than the existing sound levels, appropriate conceptual noise mitigation was incorporated into the prediction.

The existing daytime ambient sound level was previously measured as 45 dBA, and the nighttime

ambient as 39 dBA (Screening Report, 1986). The goal of this analysis was to incorporate sufficient noise control to keep the estimated sound levels significantly below the ambient sound levels.

4.1 ALTERNATIVE GRIT AND SCREENINGS DISPOSAL

4.1.1 INTRODUCTION

The grit and screenings, which are currently landfilled near the southern end of Deer Island will be removed, transported to the tip of the island, and landfilled in a manner to prevent leaching of contaminants into the soil.

4.1.2 SECURE LANDFILL ALTERNATIVE

This first alternative for the disposal of the grit and screenings will be to place them in a lined, secure landfill to be covered over with a landform. The sound level expected from this operation was predicted based on the equipment to be used. Sound level estimates of construction noise were made using the methodology of Barnes (1977), assuming equipment was operating all of the time, and the percentage of time at full load was as per Barnes.

The sound level estimate assumes hemispherical radiation, and atmospheric absorption as per the Screening Report (1986). No barriers were assumed, although the existing central drumlin forms an effective barrier for noise propagating northward. Noise propagation WNW toward the western edge of Point Shirley is relatively unimpeded.

The estimated sound level for this activity is 41 dBA for the energy average level (Leq) at the nearest neighbor on Tafts Avenue, Point Shirley. These estimated levels will occur during ideal noise propagating conditions. Often there will be additional attenuation due to absorption by the ground, wind shadows, and temperature and humidity conditions other than those of the conservative design conditions. The noise control engineering effort for this alternative is rated as minimal.

4.1.3 CHEMFIX ALTERNATIVE

The grit and screenings removal is similar for both options. However, for this alternative, the material is shredded and stabilized with Chemfix before being landfilled. The additional noise of the shredder is therefore included. The sound level expected at the nearest neighbor for this operation with the shredder is 54 dBA. In order to make the shredder noise more compatible with the daytime ambient sound level of 45 dBA at the nearest neighbor, the shredder will require a partial enclosure blocking sound propagation to the north. The shredder enclosure will reduce the total noise from this activity to approximately 44 dBA. The level of noise control required for this option is therefore rated as moderate.

4.2 OUTFALL PIPE PROTECTION

The building of landforms on the south end of Deer Island will require the construction of a protective barrier over the existing treatment plant outfall to protect it from the additional load. This activity will include excavating the existing outfall pipe, driving sheet piling on either side, and capping over with concrete. The sound levels expected from this activity were calculated at the nearest neighbor, assuming no barrier attenuation. The equipment assumed in the calculation are backhoes, a front-end loader, pile driver, compressor, mobile crane, and dozers.

Sound level estimates of construction noise were made using the methodology by Barnes et. al. (1977). It was assumed that the equipment was operating all of the time and the percentage of time at full load is as per Barnes.

The sound level estimate assumes hemispherical radiation, and atmospheric absorption as per the Screening Report (1986). No barriers were assumed although the existing drumlin forms an effective barrier for noise propagating northward. Noise propagation to the WNW is relatively unimpeded.

The estimated sound level for this activity is 38 dBA for the energy average level (Leq). Peak levels for pile driving noise are expected to be approximately 55 dBA, which can be reduced to 45 dBA with a shroud.

These estimated levels will occur during ideal noise propagating conditions. Often there will be additional attenuation due to absorption by the ground, wind shadows, and additional atmospheric absorption from temperature and humidity conditions other than those of the conservative design conditions. The noise control engineering effort for this alternative is rated as minimal.

4.3 DRUMLIN REMOVAL

4.3.1 DRUMLIN REMOVAL AND LANDFORM CREATION

The southern section of the central drumlin will be excavated and moved to allow room for primary plant construction. Most of the drumlin material will be trucked around the east edge of the island for landform creation in the prison area, since this recommended plan assumes the decommissioning of the prison by 1989.

Portions of the excavated material will also be deposited throughout the narrow northern end of the island to relocate the island access road and raise the elevation to 130 ft. and to construct a narrow noise barrier berm at the extreme northern end of the island to elevation 150 ft to provide additional noise attenuation. The dominant sources of noise from this activity are the trucks delivering the drumlin material, the bulldozers and scrapers used to shape the landforms, and the compactors to be used on the north end of Deer Island. The

expected sound level for construction of the noise berm is approximately 61 dBA at Tafts Avenue on Point Shirley. Special quiet-wheeled bulldozers will be used, supplemented by a mobile crane. Construction of this noise barrier will take approximately one month. Thereafter, landfilling construction activities required to complete the raised, northern platform area will generate an estimated noise level of 51 to 48 dBA at Point Shirley, depending on the distance to the berm.

Construction of the higher northern landform, including trucks and drumlin removal, will not be shielded by the noise berm, but will result in noise levels of 57 dBA or less due to the distance from the community. A total of 350 days will be required for this landform construction at the northern end.

For the costing plan, it is assumed that for any alternative in which the prison is still occupied, it will be necessary to modify the northern area where fill from the central drumlin is placed, relative to the recommended plan. The security fence to the north of the prison will be the southern limit of any landfilling; therefore, the northern landform must be placed on top of the southern part of the raised platform at 130 ft elevation. The access road from Point Shirley to the island will be relocated to the western shore of the neck. A noise berm will be built as in the recommended plans using quiet-wheeled dozers to shield the community from subsequent activities on the raised platform.

In summary, at Point Shirley the energy average sound level (Leq) due to construction of the noise berm and excavation of the drumlin will be 61 dBA. This exposure will occur for about one month. The sound level will generally be below 54 dBA during construction of the platform, including trucks and drumlin removal, rising above this level for a brief period when activity is near the western edge of the platform. The sound level will rise again to 57 dBA when the landform is being built on top of the platform.

At the prison, the sound level resulting from the combined activities of drumlin removal and construction of the northern landform will be 61 dBA. This sound level will gradually rise to 83 dBA as the activity comes within 100 feet of the security fence.

A lesser amount of material will be moved south to increase the elevation of the southern portion of the island to 125 feet, and to create a higher landform to elevation 175 ft at the far southern end. The expected sound level at Point Shirley for this recommended plan activity will be approximately 49 dBA, assuming that no northern landforms are yet in place.

4.3.2 SECURE LANDFILL CONSTRUCTION PLATFORM

The grit and screenings will be disposed of by placement in a lined, secure landfill to be covered with a landform. The sound level expected from this operation was predicted based on the equipment to be used, consisting of backhoes, a scraper, dozers, a compaction roller, five trucks, a grader and a mobile shovel. No barriers were assumed, although the existing central drumlin forms an effective barrier for noise propagating northward. Noise propagation WNW toward the western edge of Point Shirley is relatively unimpeded. The estimated sound level

for this activity is 47 dBA for the energy average level (Leq) at the nearest neighbor on Tafts Avenue, Point Shirley.

4.3.3 TOTAL SOUND LEVELS

As indicated in the analysis above, the sound level expected at the nearest residence for the task of securing the landfill is 47 dBA. The outfall protection task will give a sound level of 39 dBA for most of the operation, with peak levels of 45 dBA for the silenced pile driving operation. The sound level expected for moving the southern end of the central drumlin is 49 dBA.

Construction of the higher northern landform will not be shielded by the noise berm, but will result in noise levels of 54 dBA or less due to the distance from the community. A total of 350 days will be required for this landform construction at the northern end.

For the costing plan, it is assumed that for any alternative in which the prison is still occupied, it will be necessary to modify the northern area where fill from the central drumlin is placed, relative to the recommended plan. The security fence to the north of the prison will be the southern limit of any landfilling; therefore, the northern landform must be placed on top of the southern part of the raised platform at 130 ft elevation. The access road from Point Shirley to the island will be relocated to the western shore of the neck. A noise berm will be built as in the recommended plans using quiet-wheeled dozers to shield the community from subsequent activities on the raised platform.

At Point Shirley the energy average sound level (Leq) due to construction of the noise berm and excavation of the drumlin will be 61 dBA. This exposure will occur for about one month. The sound level will generally be below 51 dBA during construction of the platform, rising above this for a brief period when activity is near the western edge of the platform. The sound level will rise again to 58 dBA when the landform is being built on top of the platform.

At the prison, the sound level resulting from the combined activities of drumlin removal and construction of the northern landform will be 61 dBA. This sound level will gradually rise to 83 dBA as the activity comes within 100 feet of the security fence.

A lesser amount of material will be moved south to increase the elevation of the southern portion of the island to 125 feet, and to create a higher landform to elevation 175 ft at the far southern end. The expected sound level at Point Shirley for this recommended plan activity will be approximately 49 dBA, assuming that no northern landforms are yet in place.

4.4 ALTERNATIVE PROCESS NOISE

4.4.1 INTRODUCTION

The expected sound levels were predicted for each alternative. The categorization of the level of effort for noise mitigation proceeded as follows. If equipment is to be enclosed in a

building for weather protection, but the noise predictions indicated that acoustical material is required on the walls and ceiling and the ventilation would have to be quieted, this would be classified as a "modest" amount of noise control. Alternatively, if more expensive construction is required to contain the noise, such as the use of double wall insulated steel, sound proof doors and custom exhaust mufflers, etc., this would be classified as a difficult requirement. If no significant amount of noise control is required, this was classified as a minimal requirement.

In the evaluation of the secondary treatment options, the air compressors were a major source of noise. Their sound power was estimated, based on horsepower for both the intake and compressor casing noise. It is assumed for this analysis that the exhaust noise is controlled by the piping.

When pump noise was predicted it was assumed that the major source of noise was the motor. Motor noise was predicted based on motor horse power as per the EEI Guide (1978).

4.4.2 SECONDARY TREATMENT

Air Activated Sludge Option

This option includes air compressors and their drive motors which will be housed in the blower building. The primary sources of noise for this option are the compressor inlet and casings. The compressor casing noise for compression totalling 27,000 hp was estimated and corrected for the transmission loss of building, as per Faulkner (1976), with noise absorption materials on the inside, hemispherical spreading, and atmospheric absorption as derived in the Screening Report, for a sound level at the nearest neighbor of 16 dBA. For simplicity, the distance to the nearest neighbor for all estimates was assumed to be the same as that of the existing diesel building (2200 ft).

The predicted compressor inlet noise of 54 dBA was controlled with large intake silencers to 20 dBA. Thus, the total noise of the compressor case and intake noise is 16 plus 20 dBA, or 21 dBA at the nearest neighbor. The noise control engineering required to attain these levels was ranked as modest.

Oxygen Option

The cryogenic compressors total 12,000 hp. Their sound level was predicted in the same manner as in the option above to be 18 dBA at the nearest neighbor. The aeration equipment has 36 outdoor electric motors with a total of 4200 hp. Their expected sound level for relatively quiet motors is approximately 43 dBA. Partial enclosures may be required to lower this level to approximately 30 dBA. Full enclosures could reduce it even further, but are difficult to ventilate and will probably not be necessary. The noise control engineering required to attain these levels was ranked as modest.

Coupled System Option

This system has a total compressor hp of 17,500 plus 7200 hp of wastewater pumping capacity housed in a building. The sound levels were predicted in the same manner as above, giving a nearest neighbor sound level of 19 dBA. The noise control engineering effort required to attain these levels was ranked as modest.

4.4.3 STACKED VS UNSTACKED CLARIFICATION

The sound level from the RAS pumps (6000 hp) inside buildings was estimated to be 13 dBA at the nearest neighbor. This level would be similar for stacked or unstacked clarifiers. The noise control engineering effort required to achieve these levels was ranked as modest.

The stacked clarifier has the added advantage that it leaves space on the northern end of Deer Island for land forms which will attenuate noise, particularly construction noise.

4.4.4 GRIT AND SCREENINGS

Grit Removal, Aerated

The sound level for the motors was less than 10 dBA at the nearest neighbor. The noise control engineering effort required to achieve these levels was ranked as minimal.

Grit Removal, Centrifugal

No significant noise sources. No noise control is required an the level of effort is ranked as minimal.

Disinfection

No significant noise sources are associated with the disinfection processes.

5.0 CONSTRUCTION NOISE PREDICTIONS

5.1 DEER ISLAND CONSTRUCTION NOISE

The construction of the facility will continue over a period of approximately 12 years. During that time numerous buildings, treatment facilities and earthen landforms will be constructed. This section describes the procedure used to predict construction noise and the expected sound levels at Point Shirley during this period.

The greatest potential for noise impact at Point Shirley will occur during the early portions of the project with the construction of the earthen land forms at the northern end of Deer Island. This construction will involve the movement and placement of large amounts of earth with a potential associated noise impact. Once in place this landform will provide some shielding for the balance of construction noise.

A methodology for reducing the sound level of the construction of the berm requires that the northern edge of the berm be kept at a higher elevation than the back portion of the berm. This will provide shielding of a major portion of the earth hauling and unloading activities on the berm.

Construction noise is predicted using a methodology presented in the Power Plant Construction Noise Guide (Barnes 1977). This approach is based on actual measurements of a large number of pieces of construction equipment and the monitoring of construction noise at numerous power plant construction sites. For a given set of equipment operating in a given area, the methodology can be used to predict far field sound levels.

The method gives the expected 50 ft sound level for several sizes of each type of construction equipment commonly used. Corrections are then made for the number of pieces of each type of equipment (+10 log N), for the percent of time the equipment is operating (-10 log specified time/reference time period), and the percent of operation time that it is expected to be at full load.

The construction noise was calculated by tabulating the equipment to be used for each of the on-site construction projects for three month periods, correcting for the factors discussed above. The construction area was divided into three zones of increasingly greater distances from Point Shirley to facilitate the prediction of noise. The total sound level vs time was then calculated for each zone, correlated for the effect of the barrier, extrapolated to the nearest residence, and totaled for the three zones. The atmospheric absorption values developed by CDM and SWEC (1986) were used for the calculation.

5.1.2 BARRIER NOISE ATTENUATION

Landforms will be created along the northern end of Deer Island to provide a visual and noise barrier. The height of this landform will vary from 30 to 120 feet above the general level of Deer Island. The noise attenuation provided by the landforms is a function of several factors including:

- distance from the noise receiver to the barrier
- distance from the noise source to the barrier
- barrier height
- wind direction

The first factor, the distance from the source to the barrier is constant, but the second factor, the distance between the construction equipment and the barrier, ranges to over 4000 ft. The further the source is from the barrier, the less attenuation it provides, although hemispherical divergence attenuation increases.

The barrier height varies from elevation 160 (approximately 30 ft above the general terrain of 130 ft) to 240 ft, with an effective barrier height of 110 ft. Most of the construction work on buildings will occur behind the 200 ft elevation of the barrier, giving an effective barrier height of 70 ft.

The fourth factor affecting barrier acoustical performance is the wind direction. At great distances sound waves refract over a barrier and curve downward in the downwind direction, effectively reducing the barrier height. In a similar manner, the sound waves refract upward in the upwind direction increasing the effectiveness of the barrier.

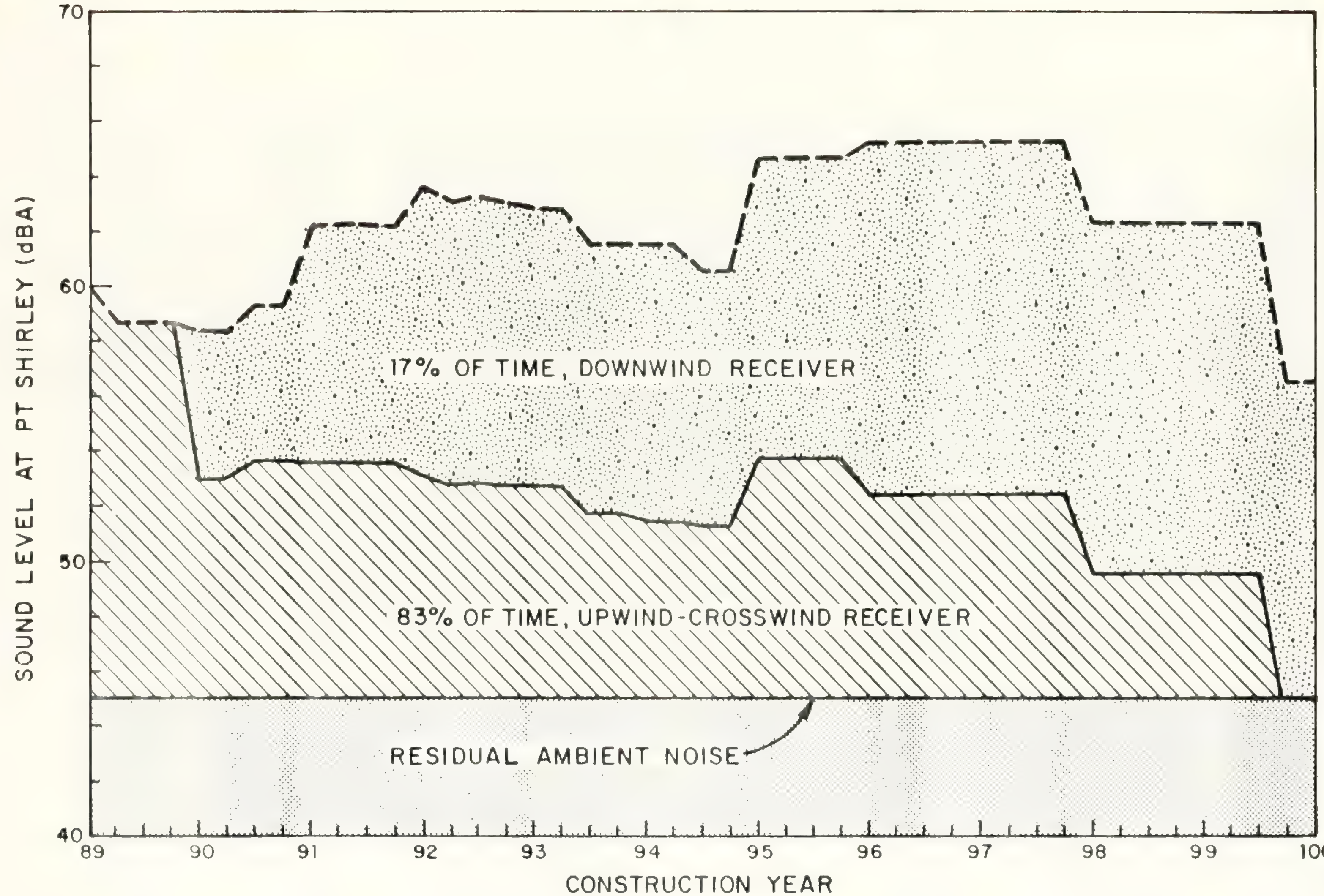
A portion of the construction noise is from the equipment building the landforms. In order to reduce the noise from the construction of the landform, the northern most edge of the landform will be constructed with quiet equipment, and will be 20 ft higher than the balance of the landform to shield the landform construction equipment from the residences. This quiet equipment consists of Terex front-end loaders which are approximately 72 dBA at 50 ft, rather than that of typical diesel driven equipment which are in the 80s.

5.1.3 RESULTS

The sound levels at Point Shirley were analyzed with landforms to include both upwind, crosswind, and downwind conditions. The crosswind conditions were represented by using the barrier noise reduction methodology of Maekawa (1971). The upwind condition was represented by a 20 dBA wind shadow. (Wind shadows typically range from 20 to 50 dBA, Beranek 1971)

Although most barrier prediction techniques do not indicate barrier degradation with wind, in order to be conservative, the approach of Kurtz and Schreiber (1986) was used to determine the worst case effect of wind on barrier performance over long distances. This would occur with winds from the S, SE, and E.

The results of the estimates are given in Figure D-3. The curves show that the projected sound levels will vary between the existing minimum level of 45 dBA for a strong upwind condition, with the receiver in a wind shadow zone to 50-54 dBA with a cross wind, where the barrier effect of the landforms are responsible for reducing the noise. This range of sound levels is expected to occur on 83% of daytime hours. During 17% of the daytime hours (annual basis), when the wind has a SE component, the sound will tend to refract over the barrier and produce levels which vary from the low 50s to the 60-65 dBA range.



MASSACHUSETTS WATER RESOURCES AUTHORITY

FIGURE D-3
PREDICTED DAYTIME CONSTRUCTION NOISE LEVELS AT NEAREST RESIDENCE, POINT SHIRLEY

The sound level contours were prepared showing construction noise for Point Shirley, representative of a loud construction period with approximately 63 dBA at the nearest neighbor. These contours are given in Figure D-4 along with the daytime ambient sound levels as previously measured. Not taken into consideration in the preparation of the contours is the 5+ dB reduction in noise observed at the site due to the barrier effect of the houses of Point Shirley for noise coming from low elevations.

This analysis has indicated that the noise barrier landform is an effective mitigation measure in reducing construction noise by about 10 dBA, for all but 17 prcent of the daytime hours. The projected range in construction sound levels of 50 to 65 dBA were compared with the existing ambient, daytime sound measurements taken at Point Shirley. As shown in Figure D-4, the existing daytime median, or L_{50} sound levels, which range from 47 dBA to 63 dBA, are similar to the projected maximum construction sound levels.

Under the worst-case conditions, downwind conditions limit the effectiveness of the noise barrir landform. Similar sound levels to the maximum projected for construction are characteristic of the area, and occur 97 percent of the daytime for about six minutes each hour.

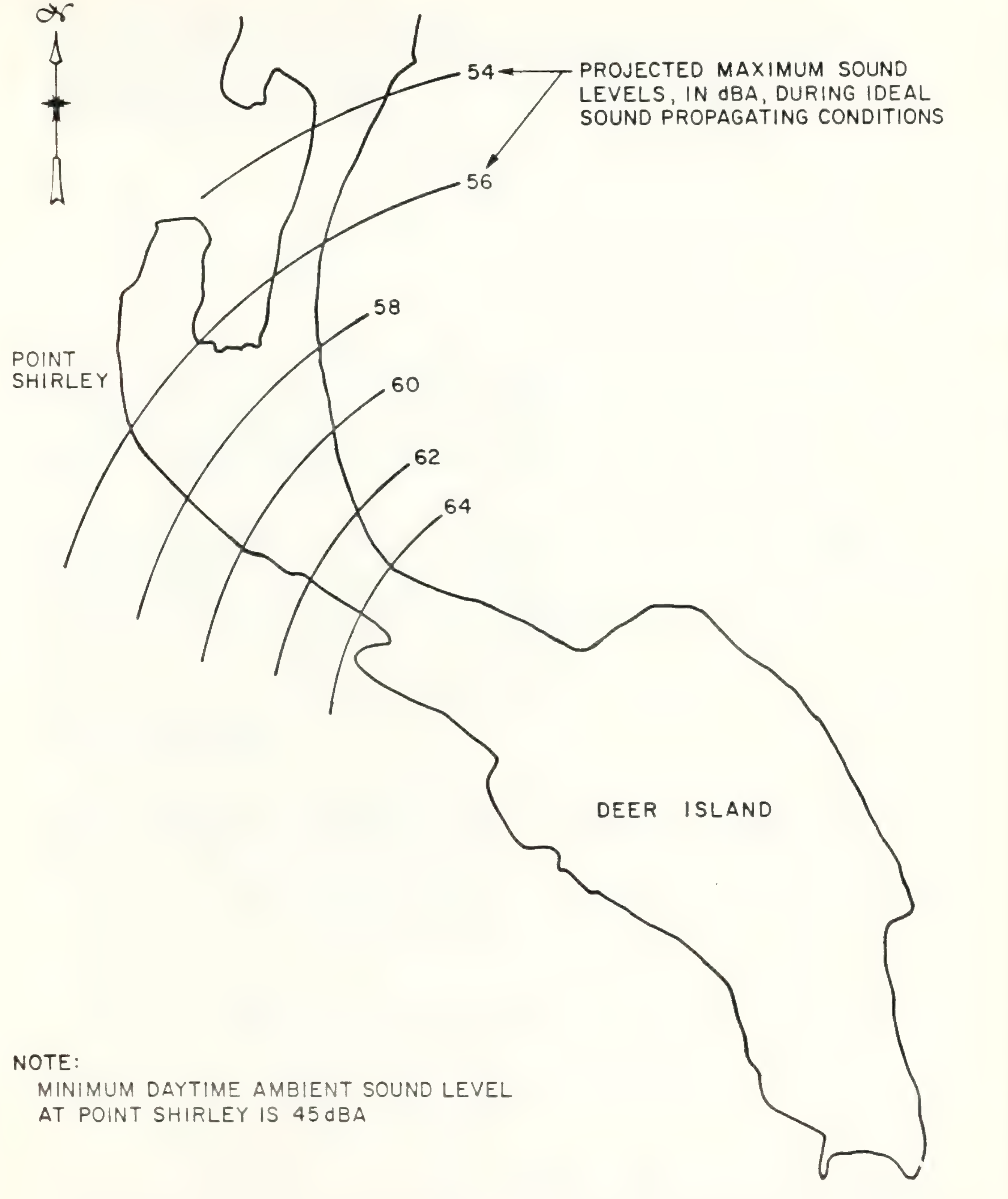
During construction, sand, gravel, and cement will arrive by barge to the bulk pier facility. The alternative delivery methodologies which could be employed (MWRA 1987) include delivery by 600-ton barge, requiring approximately 17 deliveries per week, and three hours to unload each barge. Alternatively, delivery could be by 3,000-ton barges, requiring 2.3 deliveries per week. Unloading would be by crane to conveyer.

The expected sound level from the barge unloading was predicted assuming a distance of 5,200 ft to the nearest neighbor at Point Shirley. Since it is not yet known exactly what type of equipment will be used to unload the barges, predictions were made using two different types. If a clamshell unloader is used, the level at the nearest neighbor would be an Leq of 44 dBA (S&W 1980). If a modest-size crane is used, the level would be approximately 40 dBA Barnes, et al. 1977). In either case, noise mitigation would be required to assure that the bucket does not directly strike the hopper as this could cause an impact noise much higher than that indicated.

The above noise levels are not sufficiently loud to cause a daytime noise impact, but if nighttime unloading were desired, a few dB noise reduction would be required to meet the nighttime noise limit at the property line.

5.1.4 NUT ISLAND CONSTRUCTION NOISE

The construction noise for Nut Island was predicted in the same manner as that for Deer Island, but the amount of construction to occur is very small compared to Deer Island. The primary activities consist of the demolition of the existing facility, site preparation, and construction of the new building.



MASSACHUSETTS WATER RESOURCES AUTHORITY	FIGURE D-4 MAXIMUM PROJECTED CONSTRUCTION SOUND LEVELS AT POINT SHIRLY, WINTHROP

The energy average sound levels expected from the construction is expected to be 63 dBA from mid-1992 to mid-1994, then dropping to 60 dBA for the remaining year. This will result in an approximately 10 to 13 dBA increase over the measured daytime residual sound level if approximately 50 dBA for that period.

6.0 OPERATIONAL NOISE PREDICTIONS

6.1 DEER ISLAND OPERATION NOISE

6.1.1 INTRODUCTION

The Deer Island Wastewater Treatment Facility will include a large number of pumps, compressors, motor drives, a gas turbine, etc., which have the potential for creating audible off-site noise. This section describes an analysis which was performed to identify the significant potential contributors to off-site noise, estimate their sound levels in Point Shirley, and select the conceptual noise mitigation required to minimize noise impact.

The analysis demonstrates the technical feasibility of achieving a plant sound level which will have minimal impact on the Point Shirley area. It also indicates that there is a considerable amount of equipment which will need noise mitigation, and documents the degree of noise control required. Finally, it summarizes the noise control commitments so they can be incorporated into the final noise control engineering design of the facility.

6.1.2 PROCESS NOISE PREDICTION AND CONTROL

Source Characterization

Certain noise sources such as the gas turbine generator and large compressors are loud enough to be very audible off-site, without noise abatement. Numerous other sources are significant because of the accumulative effect of a large number of secondary sources. At this point in the plant's conceptual design, detailed information about building ventilation opening size and location, and make and model of equipment, is not always available. Thus sound levels typical of the equipment to be used were incorporated into the analysis.

The sound level predictions were made as follows. Nine major noise sources locations were identified on the plot plan, each representing a process or building of the plant, as listed in Table D-10. A spread sheet was prepared for each source location which tabulated and summed the sound power levels of each contributing source at that location. Each spread sheet then calculated the total octave band sound pressure level and A-weighted sound level contribution of that source location for each community location.

The design goal of this analysis was to keep the expected plant sound level equal to, or less than, the existing nighttime residual ambient sound level of 39 dBA at Point Shirley (MWRA 1986). This goal was achieved and adopted as the acoustical design criteria for the operating facility.

TABLE D-10

SUMMARY OF PRIMARY NOISE PRODUCING EQUIPMENT FOR THE DEER ISLAND TREATMENT FACILITY

SOURCE	DISTANCE(1)	NOISE SOURCE	
1. North pumping station (in)	2250	10 @ 2000 hp electric motor pump drives (with open roll door)	
		existing pump station	
Power facility (ex)		2 @ 6000 kw diesel generators	
		25 mw gas turbine, cogeneration boiler	
		13.5 kva transformer	
2. Winthrop (in)	2480	4 @ 125 hp motor pump drives terminal	
		6 @ 600 hp waste water pumps (4 operate)	
3. Stacked 2nd Clarifiers (in)	2920	20 @ 300 hp RAS pumps	(12 operate)
		20 @ 7.5 hp WAS pumps	(12 operate)
		16 @ 40 hp scum pumps	(8 operate)
		144 @ .5 hp sludge collectors	
		8 @ 150 hp blowers	(4 operate)
5. Aeration (ex) Battery C and D	3420	6 @ 150 hp mechanical aerator motors	
		18 @ 100 hp mechanical aerator motors	
	(ex)	16 @ 20 hp selector mixers	
(in)		2 @ 75 hp 14,000 cfm fans	(1 operates)
		4 @ 50 hp purge blowers	(op. 2/mo.)
		4 @ 20 hp 500 cfm blowers	(2 operate)
7. Aeration (ex) Battery A and B	3780	6 @ 150 hp mechanical aerator motors	
		18 @ 100 hp mechanical aerator motors	
		16 @ 20 hp selector mixers	
(in)		2 @ 75 hp 16400 cfm fans	(1 operates)
		4 @ 50 hp purge blowers	(op. 2/mo.)
		4 @ 20 hp 500 cfm blowers	(2 operate)
9. Oxygen prod.in	4420	2 @ 3500 hp compressors	(1 op. except
		2 @ 2500 hp compressors 2 on 2-4 days/yr)	
		4 @ 15 hp cooling water pumps (1 operates)	
		reversing valves	
10. Primary clarifiers (in)	3700	40 @ 7.5 hp sludge pumps	(24 operate)
		8 @ 40 hp scum pumps	(4 operate)
		96 @ .5 hp sludge collector drives	

		8 @ 150 hp 1600 cfm blowers (4 operate) 2 @ 150 hp 32,600 cfm blowers (1 operates) 1 @ 100 hp 22,100 cfm blower (1 operates) 2 @ 100 hp 19,000 cfm blowers (1 operates)
11. South Pump station (in)	4200	4 @ 1250 hp electric motor pump station 32 @ 5 hp electric motor slurry pump drives (21 operate) blowers
12. Rollon-rolloff pier (ex)	3800	2 @ 40 hp motor pump drive (standard sound levels)

(1) Distance to nearest neighbor, Point Shirley, Winthrop.

Note (in) means interior- source enclosed in building
(ex) means exterior- source outside.

Where noise mitigation was found to be required, it was incorporated into the predictions using proven noise abatement methodologies. The attenuation of the silencers was, for instance, taken from catalogues. The transmission loss of building materials was based on field data or laboratory test data.

It is understood that the final design of the facility may have minor differences from the conceptual design used in this report, but the acoustical requirements will have been set forth, and mitigation measures will be modified to accommodate the changes. Sometimes community noise predictions of this complexity are made with computer programs which predict far field sound level contours based on the source sound power levels and locations. This black box approach has certain advantages in terms of ease of use, but in order to promote an open understanding of the methodologies used and to facilitate independent review of the predictions, these noise predictions have been made by computer using a spreadsheet format. All assumptions and distances used in the calculation are thus visible, and review and checking of the methodology is straight forward.

The following paragraphs discuss the methodologies used for the noise predictions. The sound power levels so derived are given in Table D-11.

<u>Compressors</u>

Compressor intake and casing sound power levels were estimated with the methodology given in EEI, 1978. It was assumed for this analysis that the exhaust noise is controlled by the piping and insulation.

<u>Pumps</u>

Pump noise predictions were based upon Miller, 1981.

<u>Motors</u>

Motor noise was estimated based on motor horse power, type of motor and need for noise control. Typical sound power levels for motors as rated by the National Electrical Manufactures Association (NEMA) for motors of standard and quiet design were taken from Harris, 1979. Where motors were used outdoors, quiet motors were usually required in the prediction.

<u>Building Attenuation</u>

It is assumed that the buildings are enclosed and that ventilation openings or fans are either of limited size and directed southward away from Point Shirley, are silenced, or both. This assumption is made because building ventilation design detail is not performed at this stage of plant design.

TABLE D-11

OCTAVE BAND SOUND POWER LEVELS FOR EACH MAJOR SOURCE LOCATION

OCTAVE BAND SOUND POWER LEVEL

NOISE SOURCE	Center Frequency in Hertz 63	125	250	500	1K	2K	4K	8K
1. North pumping station Power facility	100	100	98	103	90	84	80	77
2. Winthrop terminal	98	97	93	76	66	55	51	49
3. Stacked 2nd Clarifiers	102	98	94	87	81	72	68	63
5. Aerators	83	87	89	88	84	78	74	72
7. Aerators	83	87	89	88	84	78	74	72
9. Oxygen facility	103	99	94	91	85	96	79	87
10. Primary clarifiers	98	94	88	85	83	67	66	64
11. South Pump station	98	96	91	89	83	67	66	64
12. Roll/on-roll/off pier	94	96	98	98	100	96	92	87

Buildings are assumed to be constructed of brick and acoustical block, unless otherwise noted. This reduces the reverberant interior sound level minimizing occupational exposure to noise within the building and lower sound levels in the community. The calculation indicates that for most of the buildings complete silencing of the ventilation is not required, and that when detailed engineering of the ventilation and interior acoustical treatment of the system is performed an additional 5 to 10 dB of noise emission may be allowed from some of the buildings. This extra noise allowance for a building can be used by either relaxing the requirement for full acoustic treatment on the interior, or by allowing unsilenced ventilation.

Oxygen Production

Sources of noise associated with the oxygen production are the cryogenic compressors, reversing valves and compressor discharge valves. The compressor intake and casing noise is predicted in the same manner as the other compressors at the plant. Only one of the four compressors operate at the same time, except during plant turnaround.

The cryogenic plant has been designed with molecular sieve prepurifiers rather than the noisier reverse heat exchanger. The prepurifiers remove carbon dioxide and water vapor from the incoming air by adsorption onto a crystalline medium. To avoid clogging, the sieve is purified with nitrogen gas. With prepurification, the switch valves for purging nitrogen operate briefly only once every 8 to 12 hours, rather than the 10-minute frequency required for the reversing heat exchangers. The compressor discharge valves periodically discharge gas to atmosphere when pressure exceeds system requirements.

Sound levels have been measured from the reversing valves at two cryogenic plants which use the reversing heat exchanger. The measured levels were 90 dBA at 15 feet and 104 dBA at 10 feet respectively, from the cryogenic tower. The 104 dBA valve is extremely loud, and if unattenuated, would contribute a sound level of up to 50 dBA in the community (not taking into consideration the effect of atmospheric absorption).

The compressor discharge valves and switch valves and associated piping noise will therefore be reduced 20 to 30 dBA through the used of quiet design valves or acoustical pipe insulation, as necessary. Gas vent silencers are readily available to give 30 or more dBA noise reduction for the compressors discharge valves. The compressor intakes will be silenced.

Gas Turbine

The gas turbine used for power generation is potentially a source of off-site noise. The dominate noise components are the combustion air intake and exhaust. Additional significant sources include casing radiated noise, gas compressor noise, and air filter pulse cleaning, if used. The co-generation capability includes sources of noise such as bypass exhaust, generator, heat exchanger sidewall noise, as well as forced draft fan noise, if auxiliary boiler firing is utilized. The transformer associated with the power generation is also a source of noise.

The primary means for controlling gas turbine noise is to enclose the turbine generator inside an acoustically treated building or enclosure, as well as the use of large intake and exhaust silencers. The high frequency compressor noise from the intake is relatively easy to attenuate. Special care must be utilized, however, to attenuate the low frequency combustion noise from the compressor exhaust. In particular, attention must be given to noise in the 31 Hz octave band which, while having little effect on the A-weighted sound level, can vibrated windows and structures if not appropriately mitigated.

A gas turbine with standard silencing is approximately 65 dBA at 400 ft, the standard NEMA (National Electrical Manufactures Association) distance for measuring gas turbines. This is roughly equivalent to 50 dBA at Point Shirley, which is excessively loud. Approximately 15 dBA of additional noise reduction over standard is therefore required to bring the sound level down to approximately 35 dBA or less at Point Shirley. This corresponds to a NEMA 400-ft sound level of 50 dBA or less.

The state-of-the-art sound level design for gas turbine noise control in the U.S. is approximately 45 dBA at 400 ft for 50 MW gas turbines, so the level of noise control required is attainable. There are several gas turbine installations in this country with NEMA levels of 45 dBA. However a considerable engineering effort is required to achieve this low sound level. It is not usually possible to get information, only quotes, on very quiet units.

For the purposes of this report it is therefore specified that the gas turbine co-generation unit and its auxiliaries will be require to meet a NEMA sound level of 50 dBA or quieter at 400 ft, as well as specific octave band requirements which will prevent low frequency annoyance.

<u>Diesel Generators</u>

Sound pressure level data for the new fast-track 6000-kw diesels is based upon manufactures data. The existing Nordberg diesel pump drives are not included in the estimate because they are being replaced with electric motor drives (which are included).

6.1.3 RESULTS

Sound pressure levels were predicted using the sound power level derived as discussed above. Sound level estimates were made for each of the noise monitoring locations (MWRA 1986). The results of the predictions for the nearest neighbor on Point Shirley are given in Table D-12. As can be seen from Table D-12 the total sound level at the nearest neighbor is expected to be approximately 36 dBA. This is 3 dBA lower than the residual ambient sound levels measured in the area and will cause a less than 2 dBA increase in the existing ambient sound level under the most favorable noise propagating conditions. This change in ambient sound level will not be noticeable. Most of the time the plant will not be upwind of the community, and the sound levels will be substantially lower because of the landforms and wind shadows.

TABLE D-12

SOUND LEVEL CONTRIBUTION OF EACH NOISE SOURCE AT THE NEAREST NEIGHBOR ON POINT SHIRLEY

LOCATION	SOUND LEVEL CONTRIBUTION, dBA
1. North pumping station Power facility	35
2. Winthrop terminal	12
3. Stacked 2nd Clarifiers	22
5. Aeration	18
7. Aeration	17
9. Oxygen facility	20
10. Primary clarifiers	15
11. South Pump station	16
12. Roll/on-roll/off pier	28
TOTAL	36

The projections indicate that the most dominant noise sources are the gas turbine, the existing pump station open door, and the roll-on/roll-off pier pump. It is not known at this time who will own and control the pier pumps, (they may be on a ship), so no noise mitigation was assumed in the prediction. The sound level contribution of the other individual sources is relatively minor.

The sound level of each of the sources appears to be very low when considered individually. However, there is not as much allowance for excess noise as may appear. For instance, the seven quietest sources, when grouped together, totaled 27 dBA. If each of these sources were 5 dBA louder, their total would be 32 dB, which, when added to the 35 dBA from power generation, would give 37 dBA. If they were each raised by 10 dB, the total would be 40 dBA. It can thus be concluded that an additional 5 dB can be allowed for building ventilation or other miscellaneous sources without impacting the site criteria of 39 dBA.

The proper acoustical design for building ventilation systems is an important part of the plant noise mitigation. For instance, for a building one hundred feet square, the sound coming from an opening in the wall of one yd^2. facing the residential area would exceed that coming through the walls of the balance of the building. If that opening were on the south side of the building, however, it could be perhaps 20 times bigger before it had the same impact on building noise. Also, if sound-absorbing material does not cover the entire interior of the building, there will be a reverberant buildup of noise which will, in turn, increase the exterior sound level of the buildings.

The acoustical design of all the buildings will have to be handled with considerable care to assure that all the necessary equipment is purchased at the appropriate sound level and is properly enclosed. Attention will have to be given to the location and size of building openings such as roll doors, ventilation louvers, ventilation fans, etc. It is equally important that all exterior motors be purchased at the appropriate low noise level and that fans and blowers be silenced as required.

6.2 NUT ISLAND OPERATIONAL NOISE

The new headworks facility will provide preliminary treatment to the South System flows prior to conveyance to Deer Island. The screenings building will contain equipment for screening and grit removal but will not contain much large, loud equipment. It will be fully enclosed and the sound levels at the nearest residential area are expected to be less than 25 dBA.

The daytime residual ambient sound levels have been approximately 50 dBA on Nut Island. The nighttime ambient sound level has not been measured, but it would be expected to be approximate 30 to 35 dBA or greater. The screenings building noise will therefore not be audible at the nearest residential area.

7.0 NOISE CONTROL ENGINEERING

7.1 INTRODUCTION

The detailed design and construction of the project will take a number of years to engineer. During that time hundreds of noise mitigation tasks will have to be performed at the appropriate time and in the right sequence to meet the required interior and exterior noise goals. Dozens of pieces of equipment will have to be purchased to maintain an appropriate sound level. Noise mitigation equipment such as silencers will have to be specified and purchased.

In order to achieve these goals a systematic approach to noise control engineering is required. The approach should be sufficiently organized to accommodate problems such as job delays, changes in staff, and changes in facility design. This section outlines the recommended key elements of the engineering effort and tasks to be performed by a noise control engineer in order to achieve the required results.

The key operating philosophy for success is that the noise control engineer (NCE) assumes complete responsibility for the facility noise control engineering. This means that he actively initiates participation in all the required project interaction including specifications, bid review, installation, etc.

7.2 NOISE CONTROL PLAN ELEMENTS

The key elements to be included in the noise control engineering effort are as follows:

7.2.1 ACOUSTICAL MODEL

An acoustical model should be developed which includes the sound power level of all major sources, the anticipated noise reduction for each source, and the total sound level at the nearest neighbors. This model not only confirms the total facility sound level at the nearest neighbor, but also gives the individual allowable contribution of each source.

7.2.2 PROJECT TRACKING SYSTEM

The NCE must develop a system which allows tracking of all noise control activities associated with the project. This system should continuously provide for each item of equipment, the status and required task dates for noise criteria development, noise specification insert, comparison of bids, noise control requirement decision, noise control engineering, incorporation of recommendations into project design, and purchase of noise control hardware. This system will provide for the timely integration of noise control engineering into the project, and will allow the status of the project to be assessed at all times.

7.2.3 ACOUSTICAL CRITERIA

The allowable sound level for each significant contributor to community sound level should be defined from the computer model for input in the bid and purchase specifications.

7.2.4 NOISE SPECIFICATION PREPARATION AND INPUT

The noise specification must be specific for each piece of noisy equipment being purchased, specify the appropriate noise levels, realistically reflect the capability of the industry to quiet equipment, and be inserted into the bid purchase specification in a timely manner.

7.2.5 COMPARISON OF BIDS

The purchase bids on major noise sources must be evaluated for conformance with noise requirements. Often bids do not provide the information requested and judgements and interpretations are required. Discussions with suppliers and vendors may be necessary to resolve problems.

7.2.6 NOISE CONTROL ENGINEERING

Where suitably quiet equipment cannot be purchased, noise mitigation must be added as appropriate. This may include silencers, acoustical pipe lagging, architectural treatment, enclosures, etc. These items must also be purchased and installed correctly.

7.2.7 COMMITMENT TRACKING

When noise control recommendations are made, the recommendations must be tracked to ensure that they are incorporated into the project design. Where the initial recommendations are not feasible, alternate recommendations must be made.

7.3 NOISE MONITORING PROGRAM

It is recommended that construction and operational noise be monitored to assure compliance with the site design criteria. The construction noise will be highly dependent upon wind direction, but will, on occasion, be sufficiently loud to measure with continuous monitors. However, because of the other noise sources in the area, any construction noise audible off-site will be mixed with aircraft and other noise, so considerable attention must be given to interpretation of the data.

Both staffed and unstaffed surveys of construction noise should be conducted periodically or continuously to determine compliance with the anticipated levels and to determine if excessive noise is being created by any unusual process which can be controlled. In addition, a construction noise hot-line should be established for neighbors to register complaints. Complaints should then be investigated to determine if alternate construction approaches can be

taken to mitigate the noise.

The plant operation should not be loud enough to contribute significantly to noise levels off-site. However, after plant startup, a noise survey should be taken to measure the sound level of major sources to determine if they are as quiet as anticipated, especially where a premimum has been paid to purchase quiet equipment. Measurement should also be made at various locations between the plant and the nearest neighbors. These measurements should be made at night during periods when the wind has a SE component.

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Secondary Treatment Facilities Plan

Volume III

Appendix E
Air Emissions

PEI Associates, Inc.
Cincinnati, Ohio
and
Camp Dresser & Mckee
Boston, Massachusetts

APPENDIX E - VOLUME III

TABLE OF CONTENTS

APPENDIX E - VOLUME III

TABLE OF CONTENTS
(Continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES
(Continued)

1.0 SUMMARY

This appendix investigates the emissions of odor-causing compounds and volatile organic compounds (VOCs) from the Deer Island treatment plant and the Nut Island headworks, and the impacts of these emissions on ambient air quality. The other headworks, which are currently undergoing renovation, are not included in this assessment. Their impacts will be reviewed after their renovation is complete, and sampling is conducted.

The Commonwealth of Massachusetts has laws and regulations dealing with odors and VOCs. The laws for odors are set in general terms and seek to avoid nuisances. The laws and regulations for VOCs have specific numeric limits, however. These limits are set in regulations on two levels: 1) increase in emissions of VOCs, and 2) the ambient impact of individual compounds. The first concern sets limits on the total mass of VOCs emitted, and the second concern sets Allowable Ambient Levels (AALs) that should not be exceeded.

The sources of emissions from wastewater treatment are interfaces between wastewater and air, and emissions increase where the surfaces are turbulent. At the facilities proposed for Deer Island, the sources would be tank surfaces (such as clarifiers), weirs, and aeration tanks. For tank surfaces, wind increases emissions of volatiles. For aeration tanks, biodegradation removes some of the volatile organics.

Emissions from several sources were calculated, and their effects on ambient air quality were assessed. The sources included in these calculations were:

- o Weirs after the grit removal facilities
- o Primary splitter box
- o Weirs after primary clarifiers
- o Secondary splitter box
- o Aeration basins and their weirs
- o Secondary clarifier surfaces and weirs
- o Surface of disinfection basins.

Emissions from the grit-removal facilities and from the surface of the primary clarifiers were not estimated, because their amounts would be insignificant in comparison to the other emissions. These two surfaces will be quiescent and will be protected from the wind by covers. However, their emissions will be collected and treated, as will emissions from other minor sources such as vent shafts, Winthrop Terminal, the grit classifier building, aerated channels, and the screenings building.

All facilities up to the secondary clarifiers will be enclosed or covered. Their exhaust air will be collected and treated by wet scrubbing followed by activated carbon, at seven locations on the site. This treatment will decrease emissions of reduced sulfur by about 95 percent, and of VOCs by about 85 percent. The level of control proposed has been designed to meet the requirements for application of BACT (Best Available Control Technology).

Emissions of VOCs before and after control were estimated, and compared to existing emissions at Deer Island and Nut Island. After control, the emissions from Deer Island and Nut Island will be less than existing emissions. This means that the air pollution control facilities will not have to meet rules for LAER (Lowest Achievable Emission Rate). LAER would have had to be met if the total emissions exceeded existing emissions by more than 40 tons per year.

Air-quality modeling consisting of screening and detailed analyses were conducted. Projected impacts were compared to AALS. The comparison shows that the emissions after control will produce ambient impacts that are less than AALs for all but one constituent.

Additional study is recommended to resolve some questions about emissions of odors and VOCs. The sampling program measured VOCs from the EPA priority-pollutant and hazardous-substance lists, and other VOCs identified from searches of peaks on mass chromatographs. However, other VOCs, in addition to those measured, could be emitted. These other VOCs include volatiles already in the wastewater and volatiles produced during wastewater treatment. Data are lacking on these two types of emissions, and studies need to be under taken to assess their importance.

2.0 INTRODUCTION

Air pollutants in several forms can be released from wastewater treatment plants. Pollutants are released to the atmosphere during fuel storage and combustion in the form of gases and particulates; during the wastewater treatment processes in the form or gases and aerosols; and during the handling and ultimate disposal of the sludges produced in the form of gases and particulates.

Consideration of emissions from wastewater treatment plants is important because these emissions can cause odors and, if excessive, can pose health hazards. In addition, the volatiles under consideration in this Appendix can react in the atmosphere to form ozone, an air pollutant that is irritating to the eyes and lungs, and which produces a summertime haze during stagnant conditions. The results of the investigations conducted dealing with the emissions of these pollutants and their control are presented in this Appendix.

The potential emissions of concern are those typically described as fugitive emissions, i.e., those typically escaping capture and control. The emissions being considered are the volatile constituents present in the wastewater that can be released as gases or aerosols at various points in the treatment process. They are generally classified as volatile organic compounds (VOCs) and odor-producing compounds. In the case of the Massachusetts Water Resources Authority (MWRA) assessment, however, these typically fugitive emissions are proposed for capture and control so as to minimize the environmental impact of the MWRA's operations.

This Appendix presents the methodology applied to assess the impacts of emissions of odor-causing compounds and VOCs from the Deer Island treatment plant and the Nut Island headworks, and presents the obtained results. This Appendix deals exclusively with the potential emissions resulting from treatment of wastewater at Deer Island and from the headworks facilities proposed for Nut Island. Emissions from other headworks that are now undergoing renovation are not included in this assessment. Their impacts will be reviewed after the renovations are complete, and sampling is conducted.

Issues related to power generation and sludge handling and disposal are also not considered. Emissions from power generation are covered in Appendix H. Emissions from sludge handling will be covered in the Solids Management Plan.

2.1 BACKGROUND

MWRA identified the potential release of VOCs and their subsequent impact on the environment as a key issue in the proposed improvements to the wastewater treatment facilities. To attempt to answer the questions dealing with environmental impacts and to resolve the uncertainties in emissions from wastewater treatment facilites, a detailed study was undertaken as part of the facilities plan. This study attempted to estimate the quantity of VOC emissions from the plant, determine the potential impact on the surrounding area, determine the regulatory requirements pertaining to the proposed construction, and devise a control scheme to maintain

the worst-case impact to below allowable levels. Throughout each step of the assessment, attempts were made to use the most accurate and current information on the behavior of these constituents in wastewater and the mechanisms leading to their release to the atmosphere. The results of these endeavors are presented in detail in this Appendix.

In brief, the methodology used to conduct the assessment was as follows:

Individual VOCs present in the wastewater entering the proposed treatment plant were identified and quantified.

The magnitude of VOC emissions from the plant were estimated using computerized mass-transfer programs. Estimates were provided for a worst-case day and for an average annual emission rate.

The cost of controlling these air emission to a level as required by the Commonwealth of Massachusetts was evaluated.

The air quality impacts of the emissions escaping control at all locations of public access surrounding the proposed treatment plants were estimated.

2.2 ORGANIZATION

The remainder of this Appendix is divided into sections dealing with the various aspects of the assessment. Section 3 presents an overview of the regulatory requirements that were considered during the assessment. Section 4 presents the results obtained from a series of detailed sampling programs aimed at identifying pollutants present in the wastewater. Section 5 discusses the procedures used to quantify the fraction of the influent pollutants that are released to the atmosphere, and presents the results of the calculations for a number of possible worst-case operating scenarios. Section 6 discusses the alternatives available for controlling the air pollutants released from the wastewater treatment plant and provides a description of the proposed control system. Finally, Section 7 presents the methodolgy used to estimate the ambient air quality impacts of the pollutant releases and compares the calculated impacts with levels that are allowable.

3.0 REGULATORY REQUIREMENTS

3.1 DEFINITIONS

Section 310 CMR 7.00 of the Massachusetts Air Pollution Control Regulations defines a volatile organic compound (VOC) as "any compound of carbon (excluding carbon monoxide, carbonic acid, metallic carbides or carbonates, ammonium carbonate, methane, and ethane) that has a vapor pressure greater than 0.10 mm of Hg (0.0019 psi) at a temperature of 20 degrees Centigrade (68 degrees Fahrenheit)."

For evaluations of the impact of VOCs on ozone production, 1,1,1 trichloroethane and trichlorotrifluoroethane, both of which fall under the definition in Section 310 CMR 7.00, are not considered. Both have low potential for photochemical reaction.

3.2 REVIEW AND APPROVAL PROCESS

Both the U.S. Environmental Protection Agency (EPA) and the Commonwealth of Massachusetts have adopted regulations for review and approval of new or modified sources of air pollutants before construction. The regulations specify procedures for obtaining preconstruction approval of a new or modified source and present topics that must be considered during the planning phase. Specific source performance or impact requirements exist for "criteria" air pollutants (particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, lead, and photochemical oxidants or ozone), hazardous air pollutants (arsenic, mercury, beryllium, benzene, vinyl chloride, radionuclides, and asbestos), and some specific sources as defined by the New Source Performance Standards (NSPS). The requirements for ozone are defined in terms of VOCs which, in Massachusetts, include all non-methane hydrocarbons (NMHC) with a vapor pressure greater than or equal to 0.1 millimeters of mercury (mm Hg).

Implementation of preconstruction source approval procedures is based on the extent of existing air contaminant levels in the area of the proposed construction and the magnitude of the air pollutant emission increases resulting from the proposed source. For the purpose of determining which procedures apply, the ambient criteria air pollutant concentrations existing in each area of the U.S. are compared with the levels prescribed by the National Ambient Air Quality Standards (NAAQS). Areas that display pollutant levels less than those prescribed by the NAAQS are classified as attainment areas, and proposed major-source construction is subject to rules for Prevention of Significant Deterioration (PSD). Areas with pollutant levels greater than the NAAQS are classified as nonattainment areas, and proposed major-source construction is subject to the rules of nonattainment review and to emission offsets. The appropriate set of rules is applied to all new major sources (those with the potential to emit 100 tons or more of a specific air pollutant) and all major modifications to existing major sources (those with the potential to increase the air pollutant emissions by a significant amount). With respect to a major modification, significant is defined on a pollutant-specific basis in 310 CMR 7.00 Appendix A for nonattainment areas and 40 CFR 51.21(b)(23)(i) for attainment areas. Both of these regulations define a significant VOC increase as 40 tons per year. Proposed minor-source construction must be reviewed to ensure that an NAAQS is not

exceeded or that a nonattainment situation is not worsened.

In addition to the established requirements for preconstruction review, informal review requirements are often applied during the approval process. These requirements help to ensure that the releases of potentially toxic air pollutants not otherwise covered by regulation do not produce an ambient impact that would pose an undue risk to members of the public. Although toxic emission review is performed differently in each state, the general concept involves comparison of the ambient impact of acutely toxic compounds to safe levels based on sensitive populations, and comparison of the ambient impacts of chronically toxic compounds to a specific allowable risk level.

The concern regarding emissions from the proposed Deer Island facility is related to preconstruction review on two levels: 1) review of the VOC emission increase from the proposal, and 2) review of the ambient impact of individual potentially toxic compounds. The area in which the proposed construction will take place is classified as nonattainment for ozone: thus, nonattainment review is required for the VOCs. The VOC review first entails determining the extent of emissions baseline. If the baseline emission rate is greater than or equal to 100 tons of VOCs per year, the existing source is classified as a major source. A proposed VOC emission increase of 40 tons or more per year at a major source requires that the proposed source reduce its air pollutant emissions through the application of technology capable of Lowest Achievable Emission Rates (LAER). The emission increase must be offset by reducing VOC emissions at another existing source. A less-than-significant VOC emission increase at a major source, or a non-major new source, must apply the Best Available Control Technology (BACT) to reduce its potential VOC emission.

Air toxic review entails determining that the emission rates of potentially toxic air pollutants from the entire proposed facility do not cause incremental ambient air pollutant concentrations in excess of Allowable Ambient Levels (AALs). The AALs represent the maximum allowable ambient air quality impacts of pollutants released from the proposed facility at any point accessible to the public. Unlike the NAAQS, air toxic review does not entail a definition of existing ambient concentration for pollutants undergoing review. Massachusetts reviews the impact of toxic air pollutants using the procedure described in a report entitled The Chemical Health Effects Assessment Methodology and the Method to Derive Allowable Ambient Levels (CHEM/AAL)1.

3.3 BASELINE CONDITIONS

A definition of baseline conditions must be established prior to determining the level of VOC control that must be applied to the proposed source. A baseline is determined for an entire facility (as opposed to a single unit within a facility), and is generally representative of its routine, actual operation during the two-year period immediately preceding the application date (310 CMR 7.00 Appendix A (2)). The Massachusetts Department of Environmental Quality Engineering (DEQE) considers each of the existing and proposed wastewater project elements as "sources" to be reviewed and regulated separately, with the baseline condition representing conditions in existence or permitted as of December 31, 1986. Two sources are considered in this Appendix -- the Deer Island plant and the Nut Island headworks. The other headworks are

undergoing renovation, and their impacts will be reviewed after their renovation is complete, and sampling is conducted.

The significance of the baseline condition is that it is used to define whether or not an existing source is a major source of air pollutants. A source is defined as major or non-major on a pollutant-by-pollutant basis. In the case of the Deer Island project, the existing source is a major source when the baseline emission rate of VOCs is equal to or greater than 100 tons per year (tons/yr). No such designation exists for sources of potentially toxic air pollutants, as all new or modified sources must undergo the same level of preconstruction review.

3.4 APPLICABLE REQUIREMENTS

3.4.1 REQUIREMENTS ON ODORS

In Massachusetts, odors are regulated by Boards of Health and the State Department of Health, by the Division of Air Pollution Control, and by the Division of Water Pollution Control. The Boards of Health and the Department of Health obtain their authority from Massachusetts General Law, Chapter 111, Section 122. The Division of Air Pollution Control is empowered by the Massachusetts Air Pollution Control Regulations (310 CMR 7). The Division of Water Pollution Control relies on Massachusetts General Law, Chapter 83, Sections 6 and 7.

None of these laws and regulations sets numerical limits for odor. Rather, these regulations state limits for odors only in general terms. These limits attempt to eliminate nuisances and to avoid injury to the public health. However, specific limits have been investigated and odor thresholds have been used in assessing the impact of odor-producing compounds.

3.4.2 REQUIREMENTS FOR VOC CONTROL

DEQE regulations for control of new or modified sources do not present pollutant-specific or source-specific requirements for wastewater treatment facilities. General provisions can be found, however, in 310 CMR 7.02. This regulation requires that all new or modified sources of air pollutants include, at a minimum, application of the BACT to control VOC discharges. A modification to an existing major source must incorporate equipment capable of meeting LAER to control VOC discharges if it is determined that after the application of BACT, the proposed increase above the baseline emission rate is greater than or equal to 40 tons/yr. This emission increase must also be offset by obtaining an equal reduction (plus an additional ten percent reduction) in the level of VOC emissions from an existing source so as to demonstrate reasonable further progress toward attainment of the O3 NAAQS. Details on the definitions of BACT and LAER are provided in Section 6 of this Appendix.

Based on the emission calculation procedures documented in Section 5, the proposed Deer Island facilities will emit 98.2 tons/yr of individual volatile constituents before control. Application of controls to these emissions will reduce the amount released to 14.7 tons/yr. Based on the ratio discussed in Section 4.4, the total VOC emission rate, after application of BACT, will be between 293 and 734 tons/yr on Deer Island. The baseline emission rate is between 810 and 2,000 tons/yr. Thus, at the completion of the secondary treatment system upgrade, the emission of both individual air pollutants and total VOCs will be reduced when compared to baseline conditions. Similar conclusions are derived based on Nut Island emission rates. As a result, the determination has been made that the proposed construction on Deer and Nut Islands is subject to BACT control of VOCs. LAER is not needed and emission offsets will not be required. Details on the conclusions provided are presented in Sections 5 and 6.

3.4.3 REQUIREMENTS FOR CONTROL OF INDIVIDUAL POLLUTANTS

Satisfaction of an air pollutant control level is only part of the required preconstruction review process. The ambient impacts of individual constituents must also be less than levels

prescribed by the AALs. The AALs developed by DEQE represent the maximum allowable 24-hour ambient concentrations that can be produced by emission of certain pollutants from the proposed facilities. As is consistent with air toxic review in other areas of the country, compliance with the AALs in Massachusetts requires that the calculated incremental ambient impact be less than the AAL at all locations of public access beyond the fence line of the facility. For odor-causing compounds, odor thresholds were used is assessing the impact on ambient levels at the fence line.

Finally, PSD regulations (40 CFR 51.21) require BACT review in attainment areas for a variety of non-criteria air pollutants released in significant amounts. Although the project is not subject to PSD review for VOCs, other air pollutants will trigger the PSD review requirements for these non-criteria pollutants. With respect to the wastewater treatment facilities, the only other pollutants requiring specific PSD review are the compounds included in the category "total reduced sulfur" (TRS). These include hydrogen sulfide, mercaptans, and carbon disulfide. The significant emission rate for TRS is 10 tons per year.

3.4.4 DERIVATION OF ALLOWABLE AMBIENT LEVELS

The individual constituents considered in this assessment and the AAL for each constituent are listed in Table 3.4.4-1. The odor threshold levels for some of the pollutants are also provided. AALs for all constituents listed in Table 3.4.4-1 were obtained from DEQE's list of AALs (1) or were calculated and submitted to DEQE for review and concurrence. Constituents for which no AAL has been derived are also identified.

The ambient impact of each individual constituent was calculated based on the emission estimation procedures presented in Section 5 and the dispersion modeling procedures presented in Section 7. The impact of each constituent was compared with the most stringent ambient concentration level shown in Table 3.4.4-1 (i.e. AAL or odor threshold) to determine whether the impacts of the treatment facilities were within allowable or acceptable limits.

TABLE 3.4.4-1
Allowable Ambient Levels for Individual Constituents in the Treatment Plant Influent

Constituent CAS No	Name	Odor Threshold, $\mu g/m^3$	Allowable Ambient Level, $\mu g/m^3$
67-64-1	Acetone	240000	8000
71-43-2	Benzene	15000	1.2
100-51-6	Benzyl alcohol	24700	NA
74-83-9	Bromomethane	NA	NA
78-93-3 2-	Butanone (MEK)	29900	160
36687-98-6	2-Butanone, 3-methoxy, 3-methyl	NA	NA
75-15-0	Carbon disulfide	663	NA
108-90-7	Chlorobenzene	980	.63
67-66-3	Chloroform	10^6	1.44
95-48-7	o-Cresol	1170	NA
106-44-5	p-Cresol	2.02	12
95-50-1	1,2-Dichlorobenzene	24400	82
624-92-0	Dimethyl disulfide	5.0	NA
75-18-3	Dimethyl sulfide	2.57	NA
100-41-4	Ethyl benzene	615000	20
60-29-7	Ethyl ether	2550	160
108-10-1	Hexone (MIBK)	1950	280
74-93-1	Methyl mercaptan	4.19	NA
75-09-2	Methylene chloride	8000	2.4
91-20-3	Naphthalene	NA	14
86-30-6	N-Nitrosodiphenylamine	NA	NA[2]
62108-41-2	Pentane, 2-meth, 2,4,4-trimethyl	NA	NA
108-95-2	Phenol	195	52
403-51-3	2-Propanone, 1-flouro	NA	NA
100-42-5	Styrene	639	39
79-34-5	1,1,2,2-Tetrachloroethane	3480	1.2
127-18-4	Tetrachloroethene	34400	0.18
108-88-3	Toluene	649	51
540-59-0	Trans-1,2-dichloroethylene	341	108
71-55-6	1,1,1-Trichloroethane	553000	1300
79-01-6	Trichloroethene	272000	20.4
75-69-4	Trichlorofluoromethane	NA	762
	Xylene	220	59

1 No data available.

References for Section 3

The Chemical Health Effects Assessment Methodology and The Method to Derive Acceptable Ambient Levels, Prepared by The Commonwealth of Massachusetts, Department of Environmental Quality Engineering, June 1985. With updates issued May 14, 1987.

General References for Derivation of Odor Thresholds and Allowable Ambient Levels:

U.S. Environmental Protection Agency. Guidelines for Carcinogen Risk Assessment, 51 FR 33992-34054, September 24, 1986.

U.S. Environmental Protection Agency, Superfund Public Health Evaluation Manual, EPA 540/1-86-060, OSWER Directive 9285.4-1, October 1986.

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4.0 POLLUTANTS TO CONSIDER AND THEIR QUANTITIES

4.1 DEFINITION OF VOLATILE ORGANICS

Compounds are defined as volatile or non-volatile according to their vapor pressure. The Massachusetts Air Pollution Control Regulations (310 CMR 7) define a volatile organic compound (VOC) as "any compound of carbon (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides, or carbonates, ammonium carbonate, methane, and ethane) that has a vapor pressure greater than 0.10 mm of Hg (0.0019 psi) at a temperature of 20 degrees Centigrade (68 degrees Fahrenheit)."

4.2 SOURCES OF DATA REGARDING QUANTITIES OF COMPOUNDS

The sampling studies conducted in Fall 1986 and Spring 1987 are described in Section 6.1 of Volume III of the Facilities Plan. The sampling program specified analyses for more than 150 compounds from EPA's Priority Pollutant List and Hazardous Substances List, and supplemented those compounds by searches of mass spectrographs to identify and quantify other organic compounds.

For analysis of air emissions, only the detected pollutants having a vapor pressure higher than 0.1 mm Hg, as defined in Massachusetts regulations were included. Most of these pollutants were part of the "volatile" fractions of the Priority Pollutant List, but some were also measured under the acid and base/neutral analyses.

The procedure for statistically analyzing the results and for projecting loads and flows to the design year are described in Section 6.2 of Volume III.

4.3 ESTIMATES OF FLOWS AND LOADING

The procedures for estimating the flows and mass loadings are described in Section 10.6.5 of Volume III of the Facilities Plan. These tables are included in this section and provide the concentrations of volatile organics as follows:

Table 4.3-1	Projected concentrations of volatile organics at Deer Island
Table 4.3-2	Projected concentrations of volatile organics at Nut Island
Table 4.3-3	Comparison of Annual Controlled Constituent Emission Estimates for Existing and Proposed Treatment Systems on Deer and Nut Islands.
Table 4.3-4	Short-Term Controlled Constituent Emission Estimates Under Various Flow and Load Conditions for the Existing and Proposed Treatment Systems on Deer and Nut Islands.
Table 4.3-5	Actual Short-Term Constituent Emission Estimates Under Various Flow and Load Conditions for the Existing and Proposed Treatment Systems on Deer and Nut Islands.

TABLE 4.3-1
Projected Concentrations of VOCs in Influent to Deer Island
(Includes Deer And Nut Island)

Constituent	Influent Concentration with average load and average flow = 480 MGD	Influent Concentration with average load and average low groundwater flow = 390 MGD	Influent Concentration with average load and average high groundwater flow = 670 MGD	Influent Concentration with maximum load and minimum flow = 320 MGD	Influent Concentration with maximum load and maximum flow = 960 MGD	Influent Concentration with maximum load with storm load, maximum plus storm flow = 1270 MGD
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
VOLATILES						
Bromomethane	15.57	19.17	11.16	42.74	14.25	10.77
Methylene Chloride	30.06	36.99	21.53	120.50	40.17	30.36
Acetone	96.75	119.08	69.31	414.17	138.06	151.79
Carbon Disulfide	7.90	9.72	5.66	19.44	6.48	8.77
trans-1,2-Dichloroethene	7.35	9.04	5.26	18.80	6.27	5.47
Chloroform	5.06	6.23	3.63	15.76	5.25	6.90
2-Butanone	23.69	29.16	16.97	79.37	26.46	31.61
1,1,1-Trichloroethane	11.99	14.76	8.59	35.88	11.96	11.48
Trichloroethene	10.39	12.79	7.44	34.87	11.62	11.71
Benzene	3.58	4.41	2.57	7.67	2.56	5.11
4-Methyl-2-Pentanone	18.56	22.85	13.30	51.62	17.21	22.11
Tetrachloroethene	13.62	16.76	9.76	48.26	16.09	22.66
1,1,2,2-Tetrachloroethane	8.44	10.38	6.04	19.11	6.37	5.55
Toluene	17.45	21.47	12.50	64.37	21.46	18.42
Chlorobenzene	8.03	9.88	5.75	19.68	6.56	7.40
Ethylbenzene	8.27	10.18	5.93	25.45	8.48	6.90
Styrene	8.65	10.65	6.20	20.28	6.76	9.35
Total Xylene; M, O, and P	24.66	30.35	17.67	96.52	32.17	36.41
ACID AND BASE NEUTRALS						
Phenol	15.50	19.08	11.10	50.41	16.80	15.88
Benzyl Alcohol	19.90	24.49	14.26	54.58	18.19	23.51
1,2-Dichlorobenzene	18.69	23.01	13.39	51.38	17.13	12.95
2-Methylphenol	20.37	25.07	14.59	48.92	16.31	22.31
4-Methylphenol	17.58	21.63	12.59	49.61	16.54	21.12
Naphthalene	13.01	16.02	9.32	47.94	15.98	12.64
N-Nitrosodiphenylamine	19.89	24.48	14.25	49.57	16.52	22.24
Non-Priority Pollutants						
2 Propanol	6.39	7.86	4.58	13.42	4.47	6.51

2Butanone,3Methoxy,3Methyl	6.04	7.43	4.33	12.44	4.15	6.09
Bicyclo(3.1.1)Heptane,6,6-Di	7.47	9.20	5.35	27.54	9.18	10.60
Dimethly Disulfide	6.47	7.96	4.64	14.73	4.91	6.88
Ethane, 1,1 - Oxybis-	5.99	7.38	4.29	12.63	4.21	6.12
Ethanol	6.41	7.89	4.59	14.83	4.94	6.88
Ethanol, 2 Methoxy	6.18	7.61	4.43	12.64	4.21	6.21
1 - Hexanol	6.33	7.79	4.54	13.21	4.40	6.43
Methane Thiobus	10.28	12.66	7.37	50.26	16.75	17.71
Methane Thiol	19.19	23.62	13.75	52.11	17.37	22.54
Pentane, 2 Meth,2,4,4-Trimet	6.08	7.49	4.36	12.09	4.03	6.03
Trichlorofluoromethane	9.79	12.05	7.01	19.95	6.65	9.83

TABLE 4.3-2
Projected Concentrations of VOCs in Influent to Nut Island

Constituent	Influent Concentration with average load and average flow = 150 MGD	Influent Concentration with average load and average low groundwater flow = 110 MGD	Influent Concentration with average load and average high groundwater flow = 230 MGD	Influent Concentration with maximum load and minimum flow = 100 MGD	Influent Concentration with maximum load and maximum flow = 360 MGD	Influent Concentration with maximum load with storm load, maximum plus storm flow = 360 MGD
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
VOLATILES						
Bromomethane	14.80	20.19	9.65	42.19	11.72	11.72
Methylene Chloride	26.27	35.83	17.13	178.87	49.69	49.69
Acetone	96.65	131.79	63.03	494.38	137.33	137.33
Carbon Disulfide	7.86	10.72	5.13	17.36	4.82	4.82
trans-1,2-Dichloroethene	6.39	8.71	4.17	19.71	5.48	5.48
Chloroform	3.79	5.17	2.47	10.44	2.90	2.90
2-Butanone	34.16	46.58	22.28	184.37	51.21	51.21
1,1,1-Trichloroethane	8.46	11.53	5.52	27.07	7.52	7.52
Trichloroethene	8.67	11.83	5.66	36.68	10.19	10.19
Benzene	2.80	3.82	1.83	7.78	2.16	2.16
4-Methyl-2-Pentanone	18.98	25.88	12.38	81.49	22.63	22.63
Tetrachloroethene	11.91	16.24	7.77	45.58	12.66	12.66
1,1,2,2-Tetrachloroethane	7.81	10.65	5.09	17.02	4.73	4.73
Toluene	10.25	13.97	6.68	30.34	8.43	8.43
Chlorobenzene	7.81	10.65	5.09	17.02	4.73	4.73
Ethylbenzene	6.25	8.52	4.07	20.86	5.79	5.79
Styrene	7.81	10.65	5.09	17.02	4.73	4.73
Total Xylene; M, O, and P	15.88	21.65	10.35	61.86	17.18	17.18
ACID AND BASE NEUTRALS						
Phenol	19.64	26.78	12.81	81.01	22.50	22.50
Benzyl Alcohol	23.02	31.39	15.01	75.60	21.00	21.00
1,2-Dichlorobenzene	23.41	31.92	15.27	74.66	20.74	20.74
2-Methylphenol	23.41	31.92	15.27	74.66	20.74	20.74
4-Methylphenol	14.24	19.42	9.29	61.95	17.21	17.21
Naphthalene	21.77	29.69	14.20	78.98	21.94	21.94
N-Nitrosodiphenylamine	21.85	29.79	14.25	78.63	21.84	21.84
Non-Priority Pollutants						
2 Propanol	6.44	8.78	4.20	14.05	3.90	3.90
2Butanone,3Methoxy,3Methyl	6.26	8.53	4.08	12.53	3.48	3.48
Bicyclo(3.1.1)Heptane,6,6-Di	6.26	8.53	4.08	12.53	3.48	3.48

Dimethly Disulfide	7.33	9.99	4.78	22.84	6.35	6.35
Ethane, 1,1 - Oxybis-	6.26	8.53	4.08	12.53	3.48	3.48
Ethanol	6.26	8.53	4.08	12.53	3.48	3.48
Ethanol, 2 Methoxy	6.26	8.53	4.08	12.53	3.48	3.48
1 - Hexanol	6.26	8.53	4.08	12.53	3.48	3.48
Methane Thiobus	6.26	8.53	4.08	25.34	7.04	7.04
Methane Thiol	18.87	25.73	12.31	34.93	9.70	9.70
Pentane, 2 Meth,2,4,4-Trimet	6.26	8.53	4.08	12.53	3.48	3.48
Trichlorofluoromethane	8.59	11.71	5.60	15.90	4.42	4.42

Notes:

Minimum flow equals: 100 MGD
Average flow equals: 150 MGD
Maximum flow equals: 360 MGD
Storm flow equals: 0 MGD

Average low groundwater flow equals: 100 MGD
Average high groundwater flow equals: 230 MGD

Maximum equals 2,3265 standard deviations above the mean average non-storm load.

Conversion constant = 8.34

Table 4.3-3
Comparison of Annual Controlled Constituent Emission Estimates for the Existing and Proposed Treatment Systems on Deer and Nut Islands. (tons/yr)

	Deer Island			Nut Island	
	Existing	Proposed		Existing	Proposed
Constituent		oxygen	air		
Benzene	0.64	0.20	0.20	0.09	0.01
Chloroform	0.91	0.39	0.41	0.13	0.02
Ethylbenzene	1.38	0.53	0.50	0.25	0.03
Methylene chloride	5.16	1.58	1.64	0.80	0.13
Tetrachloroethene	2.26	0.70	0.73	0.37	0.06
Toluene	3.10	0.92	0.90	0.30	0.05
Trans-1,2 dichloroethene	1.37	0.41	0.44	0.23	0.03
1,1,1-Trichloroethane	2.15	0.92	1.11	0.27	0.04
Trichloroethene	1.68	0.80	0.77	0.26	0.04
Trichlorofluoromethane	1.97	0.55	0.61	0.30	0.05
Styrene	1.47	0.64	0.71	0.23	0.04
Acetone	0.43	0.13	0.09	0.10	0.01
2-Butanone	0.00	0.02	0.02	0.08	0.00
Total xylenes	4.65	1.29	1.30	0.46	0.08
1,1,2,2-Tetrachloroethane	0.14	0.13	0.18	0.08	0.00
Methyl mercaptan	2.84	0.59	0.63	0.60	0.09
Bromomethane	2.80	1.30	1.50	0.48	0.08
2-Propanone, 1-fluoro	0.02	0.07	0.03	0.03	0.00
Carbon disulfide	1.25	0.24	0.25	0.22	0.04
2-Butanone, 3-methoxy, 3-methyl	0.02	0.06	0.04	0.01	0.00
Ethyl ether	0.09	0.10	0.12	0.02	0.00
Phenol	0.00	0.02	0.00	0.04	0.00
Naphthalene	1.29	0.64	0.64	0.58	0.10
Chlorobenzene	1.32	0.45	0.45	0.22	0.04
o-Cresol	0.00	0.00	0.00	0.00	0.00
p-Cresol	0.00	0.00	0.00	0.05	0.00
1,2-Dichlorobenzene	2.36	1.31	1.41	0.60	0.10
Benzenamine	0.00	0.07	0.00	0.00	0.00
Hexone (MIBK)	0.08	0.11	0.14	0.02	0.00
Benzyl alcohol	0.08	0.04	0.02	0.04	0.00
Pentane, 3-meth, 2,2,4-trimethyl	0.81	0.43	0.46	0.16	0.03
Dimethyl disulfide	0.00	0.02	0.00	0.00	0.00
Dimethyl sulfide	0.00	0.00	0.00	0.00	0.00
TOTAL	40.40	14.66	15.31	7.01	1.06

Table 4.3-4
Short-term Controlled Constituent Emission Estimates Under Various Flow and Maximum Load Conditions For the Existing and Proposed Treatment Systems on Deer and Nut Islands -- Air System. (lb/day)

	Nut Island		Deer Island			
Constituent	Existing Avg	Proposed Max Flow	Existing Avg	Proposed Min Flow	Proposed Max Flow	Proposed Max Strm
Benzene	0.50	0.23	3.53	1.70	1.27	1.98
Chloroform	0.71	0.31	4.98	5.09	3.98	4.92
Ethylbenzene	1.35	0.55	7.58	6.55	5.97	5.34
Methylene chloride	4.36	5.23	28.27	27.35	21.57	14.65
Tetrachloroethene	2.02	1.29	12.40	10.76	8.39	10.67
Toluene	1.64	8.08	17.01	13.97	10.97	8.56
Trans-1,2 dichloroethene	1.28	0.64	7.50	4.66	3.81	3.19
1,1,1-Trichloroethane	1.46	0.76	11.78	12.12	12.05	13.48
Trichloroethene	1.45	0.98	9.21	10.28	10.23	12.28
Trichlorofluoromethane	1.65	0.51	10.82	5.22	4.49	6.86
Styrene	1.25	0.50	8.03	6.54	5.13	6.67
Acetone	0.53	0.21	2.37	1.72	1.10	0.86
2-Butanone	0.45	0.08	0.47	0.33	0.21	0.18
Total xylenes	2.52	1.81	25.46	20.86	15.33	14.09
1,1,2,2-Tetrachloroethane	0.45	0.03	0.78	2.06	0.86	0.71
Methyl mercaptan	3.29	1.02	15.58	3.73	3.15	3.86
Bromomethane	2.61	1.36	15.35	14.57	15.22	14.11
2-Propanone, 1-fluoro	0.18	0.01	0.13	0.14	0.10	0.08
Carbon disulfide	1.21	0.49	6.86	2.18	2.23	3.53
2-Butanone, 3-methoxy, 3-methyl	0.04	0.01	0.13	0.43	0.15	0.22
Ethyl ether	0.11	0.03	0.47	1.36	0.57	0.78
Phenol	0.24	0.00	0.01	0.01	0.00	0.00
Naphthalene	3.18	2.11	7.07	9.73	7.10	4.43
Chlorobenzene	1.23	0.50	7.23	4.26	3.12	2.86
o-Cresol	0.00	0.00	0.01	0.01	0.00	0.00
p-Cresol	0.26	0.00	0.01	0.01	0.00	0.00
1,2-Dichlorobenzene	3.27	1.99	12.95	15.44	11.26	7.36
Benzenamine	0.01	0.00	0.01	0.01	0.00	0.00
Hexone (MIBK)	0.11	0.03	0.45	1.78	0.61	0.80
Benzyl alcohol	0.19	0.03	0.43	0.23	0.15	0.13
Pentane, 3-meth, 2,2,4-trimethyl	0.88	0.33	4.46	3.63	2.65	3.42
Dimethyl disulfide	0.00	0.00	0.00	0.01	0.00	0.00
Dimethyl sulfide	0.00	0.00	0.01	0.03	0.01	0.01
TOTAL	38.43	29.12	221.37	186.77	151.71	146.07

Table 4.3-5
Actual Short-Term Controlled Constituent Emission Estimates Under Various Flow and Maximum Load Conditions For the Existing and Proposed Treatment Systems on Deer and Nut Islands -- Oxygen System. (lb/day)

	Nut Island		Deer Island			
Constituent	Existing Avg	Proposed Max Flow	Existing Avg	Proposed Min Flow	Proposed Max Flow	Proposed Max Strm
Benzene	0.50	0.23	3.53	1.69	1.26	1.95
Chloroform	0.71	0.31	4.98	4.80	3.51	3.87
Ethylbenzene	1.35	0.55	7.58	6.77	6.32	5.79
Methylene chloride	4.36	5.23	28.27	26.01	19.57	12.21
Tetrachloroethene	2.02	1.29	12.40	10.15	7.37	8.30
Toluene	1.64	8.08	17.01	14.22	11.38	9.13
Trans-dichloroethene (1,2)	1.28	0.64	7.50	4.31	3.19	2.27
1,1,1-Trichloroethane	1.46	0.76	11.78	10.92	8.05	6.58
Trichloroethene	1.45	0.98	9.21	10.53	10.62	12.90
Trichlorofluoromethane	1.65	0.51	10.82	4.60	3.41	4.15
Styrene	1.25	0.50	8.03	6.16	4.52	5.24
Acetone	0.53	0.21	2.37	1.71	1.09	0.85
2-Butanone	0.45	0.08	0.47	0.33	0.21	0.18
Total xylenes	2.52	1.81	25.46	20.72	15.09	13.63
1,1,2,2-Tetrachloroethane	0.45	0.03	0.78	1.64	0.67	0.53
Methyl mercaptan	3.29	1.02	15.58	6.50	4.92	5.47
Bromomethane	2.61	1.36	15.35	13.78	10.73	7.31
2-Propanone, 1-fluoro	0.18	0.01	0.13	0.13	0.10	0.08
Carbon disulfide	1.21	0.49	6.86	2.38	1.83	2.14
2-Butanone, 3-methoxy, 3-methyl	0.04	0.01	0.13	0.40	0.14	0.20
Ethyl ether	0.11	0.03	0.47	1.08	0.44	0.58
Phenol	0.24	0.00	0.01	0.01	0.00	0.00
Naphthalene	3.18	2.11	7.07	9.69	0.70	4.36
Chlorobenzene	1.23	0.50	7.23	4.23	3.07	2.77
o-Cresol	0.00	0.00	0.01	0.01	0.00	0.00
p-Cresol	0.26	0.00	0.01	0.01	0.00	0.00
1,2-Dichlorobenzene	3.27	1.99	12.95	15.00	10.75	6.73
Benzenamine	0.01	0.00	0.01	0.01	0.00	0.00
Hexone (MIBK)	0.11	0.03	0.45	1.67	0.57	0.74
Benzyl alcohol	0.19	0.03	0.43	0.23	0.14	0.13
Pentane, 3-meth, 2,2,4-trimethyl	0.88	0.33	4.46	3.53	2.53	3.12
Dimethyl disulfide	0.00	0.00	0.00	0.01	0.00	0.00
Dimethyl sulfide	0.00	0.00	0.01	0.01	0.01	0.01
TOTAL	38.43	29.12	221.37	183.22	132.21	121.24

4.4 POLLUTANTS FOR WHICH MORE INFORMATION IS NEEDED

The VOCs identified in the sampling program are not the only organics that can be emitted from wastewater during wastewater treatment. These other VOCs include VOCs already in the wastewater and VOCs produced during wastewater treatment.

Besides the potentially toxic chemicals that were measured in the analyses conducted as part of the sampling program, the wastewater contains volatiles that are either not potentially toxic or are present individually in concentrations below detection limits. There are no good estimates of the concentrations of these compounds, but estimates of volatile organics in air spaces show that the concentrations can be considerable. At three plants in Cincinnati, gas chromatographic analysis for 24 specific compounds in air samples from the wet well and bar screen areas accounted for less than 10% of total VOCs[1].

To investigate the total VOCs, data on emissions was examined from the Chelsea Creek, Columbus Park, and Ward Street Headworks. The data showed results of analyses of indivdual potentially toxic compounds and also of flame-ionization detection (FID) measurements. The FID measurements are estimates of the total volatile organic compounds. Ideally, the sum of the individual compounds should approximately equal the FID measurement. (The two would not match, however, because the FID test measures the carbon content of a sample, rather than the total mass).

The ratios of the FID measurements were calculated, and divided by the sum of the individual species. The results are shown on Table 4.4-1. The results show that the ratio of the total VOCs to the sum of the individual species ranges from about 20 to 50 to 1. That is, for every lb of VOC measured by testing for individual compounds in air samples at the headworks, there might actually be a total of 20 to 50 lb of total VOCs. This ratio is important in estimating the potential for emissions of VOCs, and more information needs to be obtained about its magnitude. In the work for this project, data has been multiplied on the sum of individual components by 20 to 50 to estimate total VOCs.

We tried to find a statistical relationship between the ratios and parameters such as flow and total load, but were unsuccessful. Also, there is no apparent reason for the high standard deviation for Ward Street, where the standard deviation is approximately equal to the average.

Volatile compounds can also be produced in biological treatment. These compounds can include volatile intermediate products or by-products such as alcohols, aldehydes, and terpenes. From measurements on effluent and gas streams from trickling filters in Indianapolis, Wukasch et al.[2] suggested that the trickling filters produce methane and nonmethane volatile organics.

For estimates of emissions, estimates for VOCs produced during treatment were not included. Therefore the estimates of emissions from activated sludge treatment might be low. However, no other information reports on the volatile compounds produced and emitted during wastewater treatment. Measurements on the potential for formation and emission of VOCs during biological treatment need to be obtained.

Table 4.4-1
Ratios of VOCs to the Sum of Individual Species in Air Samples

Headworks	Number of Samples	Total volatile organics/sum of species: Average	Total volatile organics/sum of species: Standard Deviation
Chelsea Creek	19	21.28	7.17
Columbus Park	18	34.24	17.88
Ward Street	20	43.52	45.99

References For Section 4.4

[1] Dunovant, V. S., Clark, C. S., Que Hee, S. S., Hertzberg, V. S., and Trapp, J.H., "Volatile Organics in the Wastewater and Airspaces of Three Wastewater Treatment Plants." J. Water Pollut. Control Fed., 58, 866 (1986).

[2] Wukasch, R. F., Dieterlen, J. P., and Keramida, V., "Mass Flow Rate of Volatile Organic Compounds from Wastewater Treatment Operations." Presented at the 59th Annual Conference of the Water Pollution Control Federation, Los Angeles (1986)

4.5 AEROSOLS

Aerosols (suspensions of fine droplets in air) are produced in wastewater treatment plants by agitation and turbulence, such as in aeration or at weirs. Because of the pathogens found in wastewater, aerosols from wastewater treatment plants offer the potential for spreading disease to nearby residents. Indeed, pathogens above background levels have been found at distances up to 3,000 ft downwind from treatment plants. Nevertheless, most studies have been unable to find statistically significant increases in illness rates for residents near treatment plants.

Residents near the plant will be further protected, because all the treatment facilities, through aeration, will be covered at the Deer Island plant.

5.0 EMISSION ESTIMATION PROCEDURES AND RESULTS

5.1 INTRODUCTION

Eight combinations of activated sludge processes and wastewater flow/pollutant load conditions were selected for preliminary emissions estimation using the procedures and data described in Sections 5.2 and 5.3. The eight combinations consisted of two process variations and four conditions of flow and load. Process conditions included a diffused air system in the activated sludge process and pure oxygen feed to the activated sludge process. The four conditions of flow and load represented: average wastewater flow with average dry-weather constituent mass loadings; minimum wastewater flow with maximum dry-weather constituent mass loadings; maximum dry-weather flow with maximum constituent mass loadings; and maximum wastewater flow plus stormwater flow with maximum constituent mass loadings plus the storm constituent loadings. The rationale for selection of each emission estimate scenario is provided in Section 5.4. In general, these conditions were anticipated to produce the greatest short-term emission rate for subsequent dispersion modeling.

Computer calculations were performed on each of the selected scenarios as well as on the existing treatment system. The procedures used during emissions calculations, the program developed to perform the calculations, and the data input to each scenario are described throughout this Section.

5.2 DESCRIPTION OF REMOVAL MECHANISMS

Several mechanisms contribute to a loss of volatile compounds from wastewater treatment systems. The two major removal mechanisms were considered in this assessment -- volatilization and biodegradation. Volatilization is the only removal mechanism that leads to an atmospheric emission, and occurs when a molecule of a substance dissolved in the wastewater escapes from the liquid phase to an adjacent gas phase. The adjacent gas phase can be an air bubble within the liquid or in the atmosphere above the liquid. As such, emissions due to volatilization can occur from quiescent liquids such as those found in holding tanks or clarifiers, and from turbulent liquids such as those found at bar racks, weir overflows, and in aeration tanks. Biodegradation occurs when microbes decompose organic compounds for use in their metabolic processes. The rate of this decomposition varies by compound, depending on the compound's structure and the needs of the microbe for the compound. At a wastewater treatment plant, biodegradation occurs in the aeration tanks. Here biodegradation competes with volatilization as a removal mechanism. Thus lower air emissions are produced from the secondary treatment processes when biodegradation occurs.

In addition to the two major removal mechanisms considered, other mechanisms can also exist and these would tend to lower the amount of volatile material released from the treatment plant. These mechanisms include chemical oxidation and sludge partitioning. Chemical oxidation involves the degradation of compounds by oxygen, chlorine, or organic acids. Sludge partitioning involves the movement of a given compound from the liquid phase to the solid phase. These mechanisms were not considered in this assessment. They are less important than

the mechanisms considered, and omission of these mechanisms will maximize the calculated emission rates for all compounds considered. The emissions calculations assumed a temperature of 20^{0} C. This is the temperature for which most kinetic data have been collected, and it is higher than the wastewater temperature most of the year. Using 20^{0} C overestimates emissions because VOCs are more volatile at higher temperatures. Air quality modeling used actual meteorological data for temperatures.

The study of the mechanisms leading to atmospheric release of organic constituents from wastewater treatment plants has been pursued by various researchers over the past several years. The need to simulate releases under a variety of conditions has necessitated the development of computerized mass-balance techniques capable of performing the necessary calculations for many different unit processes. One of these techniques also coupled the calculated emission rates for individual constituents with an air pollutant dispersion model. This computer program was developed by the U.S. Enviromental Protection Agency (EPA), and combines emission estimation with dispersion modeling using the EPA-approved Industrial Source Complex (ISC) model [(1)]. Because the framework for the present assessment was already included in the previously-developed EPA model, the EPA emission/dispersion model formed the basis of all emission calculations and subsequent ambient impact assessments. The basis of the model and the necessary refinements incorporated for the Deer Island assessment are described below.

5.2.1 VOLATILIZATION FROM TANK SURFACES

Tank surfaces at the Deer Island Facility will consist of the grit chambers, primary and secondary clarifiers, and the disinfection basins. The grit chambers and the primary clarifier surface will be covered, and because volatilization from quiescent surfaces is controlled by wind velocity, only the secondary clarifiers and the disinfection basins were modeled as quiescent surfaces. The Nut Island Facilities that were modeled as quiescent surfaces include the existing clarifiers and proposed distribution channels. The basic relationship describing the mass transfer of a chemical species from an open liquid surface to the air is expressed as:

$$E = K_L AC \qquad \text{(Eq. 1)}$$

where E = air emission rate from the liquid surface, grams/second (g/s)
K_L = overall mass-transfer coefficient, meters/second (m/s)
A = liquid surface area, m^2
C = concentration of constituent in the liquid phase, g/m^3

The overall mass-transfer coefficient (K_L) can be estimated from a two-phase resistance model that is based on the liquid- and gas-phase mass-transfer coefficients and the Henry's Law constant in the form of a unit-less partition coefficient. These two resistances act in series to yield an overall resistance expressed in the following equation:

$$1/K_L = 1/K_w + 1/(K_g K_{eq}) \qquad \text{(Eq. 2)}$$

where K_w = liquid-phase mass-transfer coefficient, m/s
K_g = gas-phase mass-transfer coefficient, m/s
K_{eq} = partition coefficient

The partition coefficient is the ratio of the concentration of a constituent in the gas phase and in the liquid phase, estimated as follows:

$$K_{eq} = HLC/RT \qquad \text{(Eq. 3)}$$

where HLC = Henry's Law constant, atm m^3/gmole
R = universal gas constant, 8.21×10^{-5} atm m^3/gmole K
T = temperature, K

The liquid-phase mass-transfer coefficient is derived using a model developed by Springer et al [2]:

$$Kw = [2.605 \times 10^{-9} (F/D) + 1.277 \times 10^{-7}] U^2 [D_w/D_{ether}]^{2/3} \qquad \text{(Eq. 4)}$$

where U = windspeed at 10 m above liquid surface, m/s
(minimum value input = 3.25 m/s)
D_w = diffusivity of constituent in water, cm^2/s
D_{ether} = diffusivity of ether in water, cm^2/s
F/D= fetch-to-depth ratio (fetch is the linear distance across the impoundment)

The gas-phase mass-transfer coefficient is estimated using the correlation developed by MacKay and Matsugu [3]:

$$K_g = 4.82 \times 10^{-3}\ U^{0.78}\ Sc_g^{-0.67}\ d_e^{0.11} \qquad \text{(Eq. 5)}$$

where Scg = Schmidt number on the gas side
$= \mu\ \rho_G D_a$
μ = viscosity of air, g/cm s
ρ_G = density of air, g/cm^3
D_a = diffusivity of constituent in air, cm^2/s
d_e = effective diameter of impoundment = $(4A/\pi)^{1/2}$, m
A = area of impoundment, m^2

The individual mass-transfer coefficients, along with the calculated K_{eq}, are then applied to Equation 2 to determine the overall mass-transfer coefficient.

The flow model used in EPA's program for flow through quiescent impoundments assumes that the contents of the system are thoroughly mixed and that the bulk-concentration driving force is equal to the effluent concentration. A material balance for this flow model yields:

$$C = QC_o/(K_L A + Q) \qquad \text{(Eq. 6)}$$

where C = bulk concentration in impoundment, g/m^3
Q = volumetric flow rate, m^3/s
C_o = initial concentration of constituent, g/m^3

The well-mixed assumption is made for the sake of simplicity, and assumes that the bulk convection and wind-induced eddies combine to mix the impoundment contents. An assumed plug flow would yield slightly higher estimates; however, only minor amounts of the organic constituents will be present in the impoundments modeled with this assumption, therefore the difference should be small.

5.2.2 VOLATILIZATION AT WEIRS AND HYDRAULIC STRUCTURES

Volatilization is strongly influenced by turbulence and, as a result, weirs used for flow control throughout the treatment plant are potential emission sources for the volatile constituents considered in this assessment.There were no reports found pertaining to the magnitude of volatile emissions due to turbulence at weirs and hydraulic structures, but there is information available about oxygen transfer at these structures. (A great deal of the procedures for estimating volatile releases from treatment systems are founded on the principles and mechanics of oxygen mass transfer). For estimates of volatile releases from wastewater flowing over weirs, the mass-transfer coefficients for oxygen were calculated and corrected by the ratio of the volatility of the constituent in question to oxygen.

The change in concentration of oxygen relative to saturation concentration as a liquid flows over a weir can be shown to be [4]:

$$1/r = (C_s - C)/(C_s - C_o) = \exp(-K_L a_o t) \qquad \text{(Eq. 7)}$$

where r = deficit ratio
$K_L a_o$ = mass-transfer coefficient, 1/s
C_s = saturation concentration
C_o = upstream concentration
C = downstream concentration
t = time

For a volatile constituent with a low concentration in the atmosphere, C_s becomes equal to zero and the equation reduces to:

$$1/r = C/C_o = \exp(-K_L a_v t) \qquad \text{(Eq. 8)}$$

This equation can be rewritten as:

$$\ln r = K_L a_v t \qquad \text{(Eq. 9)}$$

This means that ratios of the logarithm of r for different gases over the same weir (same value of t) are related by the ratios of their values of $K_L a$.

Nakasone [5] has presented equations relating the values of r for oxygen over weirs with varying hydraulic conditions. He reports four equations for varying conditions:

$$\ln r_o = 0.0785\ (D + 1.5\ H_c)^{-1.31}\ q^{0.428}\ H^{0.31} \qquad \text{(Eq. 10)}$$

for $(D + 1.5\ H_c) \leq 1.2$ m and $q \leq 235\ m^3/h\ m$

where
- D = drop height, m
- H_c = critical water depth on the weir, m
- q = discharge per width of weir, $m^3/h\ m$
- H = tail water depth, m

$$\ln r_o = 0.0861\ (D + 1.5\ H_c)^{0.816}\ q^{0.428}\ H^{0.31} \qquad \text{(Eq. 11)}$$

for $(D + 1.5\ H_c) > 1.2$ m and $q \leq 235\ m^3/h\ m$

$$\ln r_o = 5.39\ (D + 1.5\ H_c)^{1.31}\ q^{-0.363}\ H^{0.31} \qquad \text{(Eq. 12)}$$

for $(D + 1.5\ H_c) \leq 1.2$ m and $q > 235\ m^3/h\ m$

$$\ln r_o = 5.92\ (D + 1.5\ H_c)^{0.816}\ q^{0.363}\ H^{0.31} \qquad \text{(Eq. 13)}$$

for $(D + 1.5\ H_c) > 1.2$ m and $q > 235\ m^3/h\ m$

For simplification purposes and as suggested by Nakasone, the term $D + 1.5\ H_c$ was assumed to be equal to the change in elevations of the liquid surfaces before and after the weir. In order to determine the fraction of an organic constituent emitted through weir turbulence, the deficit ratio for the constituent was calculated for substitution into the appropriate equation above in terms of the deficit ratio for oxygen, as follows:

$$\ln r_v = \ln r_o\ (K_L a_v / K_L a_o) \qquad \text{(Eq. 14)}$$

where the subscripts o and v denote oxygen and volatile constituent, respectively.

For highly volatile organics (Henry's Law constant > 10^{-3}), the ratio of mass-transfer coefficients can be related to diffusivity, described by Roberts [6] as follows:

$$K_L a_v / K_L a_o = (D_v / D_o)^{0.62} \qquad \text{(Eq. 15)}$$

where
- D_v = diffusivity of constituent in water at infinite dilution, cm^2/s
- D_o = diffusivity of oxygen in water at infinite dilution, cm^2/s = 1.88×10^{-5}

For low volatiles (Henry's Law constant < 10^{-3}). the ratio of Henry's Law constants can be used as follows:

$$K_L a_v / K_L a_o = (HLC_v / HLC_o)^{0.6} \qquad \text{(Eq. 16)}$$

where $HLC_o = 0.072$ atm m^3/gmole

From these relationships. the fraction of volatiles emitted during weir overflow is calculated as:

$$f = 1-(1/r_v) \qquad \text{(Eq. 17)}$$

5.2.3 VOLATILIZATION FROM AERATED SYSTEMS

Volatile constitutents entering an aeration tank are removed from the liquid stream primarily by volatilization and biodegradation. (As noted previously. the effect of other mechanisms on removal are negligible.) Volatilization occurs as the constituent is transferred from the liquid phase to the gas phase. represented by the air or oxygen bubble fed to the system. Biodegradation occurs as the activated sludge consumes organic matter for reduction of the BOD content of the wastewater. The rate of removal by both of these mechanisms in an aeration tank is highly dependant on the oxygen mass transfer rate to the liquid.

Matter-Muller et al [7] and Roberts et al [8] have investigated the removal of volatiles from liquids by bubble aeration. Their work has shown that the degree of saturation of an air bubble leaving the surface of an aeration basin. i.e.. the percent of equilibrium between the air bubble and the liquid. is a function of the mass-transfer rate and the Henry's Law constant. expressed as follows:

$$S = 1 - \exp[-(K_L a) V_L / K_{eq} Q_G] \qquad \text{(Eq. 18)}$$

where S = fraction of saturation
V_L = aeration tank volume. m^3
Q_G = aeration air or oxygen flow. m^3/s

For the aeration system at Deer Island. it has been determined that $K_L a/Q_G$ remains constant for each flow condition. This is due to the fact that at higher flow rates the amount of air or oxygen input to the system is increased to handle the higher loads. thus increasing the oxygen transfer rate. This ratio. however. is not constant between the air and oxygen feed systems. This fact. combined with the relationships provided earlier in Equations 15 and 16. is used to calculate the fraction of saturation for each constituent present in the liquid as follows:

$$S_v = 1 - \exp[-(1.5\times10^{-5})(V_L / K_{eq})(HLC_v / HLC_o)] \qquad \text{(Eq. 19)}$$

for the air feed system. and

$$S_v = 1 - \exp[-(9\times10^{-4})(V_L / K_{eq})(HLC_v / HLC_o)] \qquad \text{(Eq. 20)}$$

for the oxygen feed system. The removal rate resulting from volatilization for each constituent is then calculated based on its partition coefficient and the fraction of saturation as:

$$R_s = Q_G K_{eq} C_o S \qquad \text{(Eq. 21)}$$

where R_s = removal rate, g/s

C_o = influent concentration, g/m^3

In the case of the secondary splitter box, the influent concentration is equal to the effluent concentration from the immediately upstream treatment unit located immediately upstream (primary-clarifier effluent weir), reduced by 1/3 to account for dilution of the pollutants by the return activated sludge flow. The rate of removal due to biodegradation is calculated in a similar fashion:

$$R_b = K_b C_o V_L \qquad \text{(Eq. 22)}$$

where R_b = removal rate, g/s
K_b = rate constant for biodegradation, 1/s

These processes can be combined to estimate the effluent concentration of a volatile from a completely mixed aeration tank as:

$$C = C_o Q_L/(Q_L + K_b V_L + Q_G K_{eq} S) \qquad \text{(Eq. 23)}$$

where Q_L = liquid flow rate into the aeration tank
= wastewater flow plus return activated sludge flow

Based on previously established relationships, the fraction of the volatile constituent emitted (f) is expressed as the volatilization rate divided by the total removal rate due to volatilization and biodegradation:

$$f = Q_G K_{eq} S/(Q_L + K_b V_L + Q_G K_{eq} S) \qquad \text{(Eq. 24)}$$

The aeration basins for the Deer Island activated sludge systems will be designed to approach plug-flow units rather than completely mixed units. Plug-flow units can be modeled as a series of smaller completely mixed units, each one feeding a downstream unit. Alternately, the fraction of a volatile constituent emitted from the plug-flow units can be simulated (using the same relationships described above for volatilization and biodegradation) as:

$$f = [1 - \exp(-\{K_b + F\}V_L/Q_G)][F/(K_b + F)] \qquad \text{(Eq. 25)}$$

where $F = SK_{eq} Q_G/V_L$

The emission rate for the constituent of concern is then calculated by applying this fraction

to the constituent mass loading rate as follows:

$$E = Q_L C_o f \qquad \text{(Eq. 26)}$$

where E = emission rate, g/s

5.3 DATA NEEDED FOR ESTIMATING EMISSIONS

Several types of data are needed to perform the required calculations. The general classes of data can fall into either a constituent category or a source category. Within each of these categories, the data can either remain constant between scenarios (e.g., constituent vapor pressure or treatment system dimensions) or vary between scenarios (e.g., constituent concentration or wastewater flow rate). To estimate emissions, properties of the constituents of interest and information relevant to the system design and operating parameters were compiled from the best available information sources. Discussion of these data is presented below.

5.3.1 DATA FOR CONSTITUENTS OF INTEREST

The concentrations for the constituents of interest were presented previously in Section 4 and will not be repeated here. To facilitate the multitude of emission calculations, each constituent was assigned to a surrogate class. Some of the data used for calculations were derived from surrogate properties, while other data were input directly by constituent. Direct input was used for concentrations, biodegration rate, and removal rate in the air pollution control system; data pertaining to Henry's Law and diffusivity were derived from the surrogate properties. With the exception of influent concentrations, data for the constituents remained constant between scenarios. The data, however, were adjusted to account (as indicated in Section 5.2) for influencing parameters such as temperature and oxygen transfer rates.

Table 5.3.1-1 presents a list of each constituent considered in the assessment, grouped by the surrogate class to which it was assigned, and provides the data used in the emission calculation program. Those constituents with higher Henry's Law constants will be more likely to be removed through volatilization than the ones with lower constants. Thus, they are especially susceptible to large releases due to weir turbulance since there are no competing mechanisms involved. Biodegradation, a competing mechanism in the aeration tanks, will tend to lower the aeration tank emission rate when the constituent has a high biorate. Those constituents with both low biorates and low Henry's Law constants will tend to pass through the system and be present in the treatment plant effluent.

The data presented in Table 5.3.1-1 were compiled from a variety of sources. Information on the actual Henry's Law constants were obtained from the US EPA's documentation of their emission/dispersion model (1). These data were used to establish the surrogate groups and the Henry's Law constants for each surrogate. Actual diffusivities for each constituent were also obtained from the EPA documentation, and were used to define the diffusivity value for each surrogate group.

The biodegradation rates were based on reported rate constants from a variety of sources (1, 9, 10, 11, 12). There is generally poor agreement within the literature on biological conversion rates, and much of the data was published based on high concentrations of single constituent wastes. As a result, some judgment had to be applied to selection of the biodegradation rates presented in Table 5.3.1-1. Those constituents for which no data could be found or derived were assumed to have a biodegradation rate equal to zero.

TABLE 5.3.1-1
Properties of Constituents Considered

Surro-gate No.	Compound	Actual Properties HLC[1]	Diffu-sivity[2]	Bio-rate[3]	Surrogate Properties HLC[1]	Diffu-sivity[2]
1	Trichlorofluoromethane	5.83E-02	9.70E-06	17	7.64E-02	1.10E-05
	Trans-dichloroethene (1,2)	8.50E-02		33		
	Bromomethane	2.21E-01		0		
2	Tetrachloroethene	2.90E-02		33	2.97E-02	8.80E-06
	1,1,1-Trichloroethane	3.00E-02	8.80E-06	0		
	Carbon Disulfide	1.68E-02		0		
3	Phenol	4.54E-07	9.10E-06	75	4.54E-07	9.10E-06
	Dimethyl Sulfide			0		
	Dimethyl Disulfide		1.50E-06	0		
	Benzenamine			67		
	o-Cresol	2.60E-06	8.30E-06	70		
	p-Cresol	4.43E-07		70		
4	2-Butanone, 3-methoxy 3-methyl			0	4.22E-05	1.06E-05
	Acetone	4.08E-05	1.14E-05	67		
	2-Butanone (MEK)	4.35E-05	9.80E-06	67		
	2-Propanone, 1-fluoro			0		
	Hexone (MIBK)	4.95E-05	7.80E-06	0		
	Benzyl Alcohol	1.39E-05		70		
5	1,2-Dichlorobenzene	1.94E-03	7.90E-06	0	1.59E-03	8.04E-06
	Pentane, 2-meth, 2,4,4 trimethyl			0		
	Naphthalene	1.18E-03	7.50E-06	25		
6	Trichloroethene	9.10E-03	9.10E-06	4	7.59E-03	8.00E-06
	Ethylbenzene	6.44E-03	7.80E-06	13		
	Toluene	6.68E-03	8.60E-06	72		
7	1,1,2,2-Tetrachloroethane	3.80E-04	7.90E-06	0	5.30E-04	8.60E-06
	Ethyl Ether	6.80E-04	9.30E-06	0		
8	Chlorobenzene	3.93E-03	8.70E-06	43	4.26E-03	9.33E-06
	Styrene	3.30E-03	8.00E-06	0		
	Benzene	5.50E-03	9.80E-06	75		
	Chloroform	3.39E-03	1.00E-05	0		
	Methylene Chloride	3.19E-03	1.17E-05	5		
	Total Xylene	5.25E-03	7.80E-06	42		
	Methyl mercaptan	4.18E-03		5		

1. units of HLC are (atm-m^3/mol)
2. units of diffusivity are (cm^2/sec)
3. units of biorate are (x 10^4/sec)

5.4 APPLICATION OF PROCEDURES TO DEER ISLAND

5.4.1 SOURCES OF EMISSIONS

Major wastewater treatment facilities at Deer Island will include:

- o The North Main Pumping Station
- o Winthrop Terminal
- o South System Pumping Station
- o Grit Facilities, East and West
- o Grit Classifiers
- o Primary Effluent Screening Facilities
- o Primary Influent Channels
- o Primary Splitter Box
- o Aerated Channels
- o Primary Clarifiers
- o Secondary Splitter Box
- o Anaerobic Selector Basin
- o Aeration Basins
- o Secondary Influent Channel
- o Secondary Clarifiers
- o Secondary Sludge Pumping Station
- o Disinfection Basins
- o Outfall

Sources of odor-causing compounds and VOCs are the facilities where interfaces between wastewater and air are produced. These interfaces are produced at tank surfaces, channels, weirs, and aeration tanks. Emissions are not released, of course, from pumps and pipelines.

The emissions facilities were divided into three groups. One group includes facilities that have the potential to emit VOCs in sufficient amounts that the emissions could impact on ambient air levels. Emissions from this group were calculated and the results were used in air-quality modeling to determine the impact on ambient air quality. These facilities include

- o Grit Removal Facilities
- o Primary Splitter Box
- o Primary Clarifiers
- o Secondary Splitter Box
- o Anaerobic Selector Basin
- o Aeration Basins
- o Secondary Clarifiers
- o Disinfection Basins

The second group includes facilities that emit odor-producing compounds and VOCs in quantities high enough to require ventilation for decreasing the levels in the work environment. Air

vented from these facilities would be collected and treated before exhaust, but the small amount of VOCs released after treatment would not be included in air-quality modeling. These facilities include

- Winthrop Terminal
- Vent Shafts from North System Tunnels
- Primary Screening Facilities
- Grit Classifiers
- Primary Influent Channel
- Secondary Influent Channel
- Wet Wells From South System Pumping Station
- Secondary Sludge Pumping Station

This group also includes vent shafts from wastewater tunnels to Deer Island.

The third group includes only the outfall vent, which will have little potential for release of odor-causing compounds and VOCs. Thus exhaust would not require treatment before release to the atmosphere.

5.4.2 APPLICATION OF MODELS FOR EMISSIONS

Grit Removal Facilities

Most of the emissions from grit removal will be from the effluent weirs controlling flow from the facilities. Emissions from the flow over the weirs will be much greater than from the surface of the grit chambers. The chambers will be covered, and the covering will greatly decrease emissions. In contrast to emissions from the weir, emissions from the water surface in the grit facilities can be disregarded. Weir formulas were used to estimate emissions from the grit facilities.

Primary Splitter Box

The primary splitter box will include adjustable weirs to control flow to the primary clarifiers. Weir formulas were used to estimate emissions from the primary splitter box.

Primary Clarifiers

Like the grit removal facilities, the primary clarifiers will be covered, and the major source of emissions will be the weirs. Weir formulas were used to estimate emissions from the primary clarifiers.

Secondary Splitter Box

The secondary splitter box will include adjustable weirs to control flow to the aeration tanks. Weir formulas were used to estimate emissions.

Anaerobic Selector Basin and Aeration Tanks

Emissions from the anaerobic selectors will be small compared to the emissions from the aeration tanks and from the weirs at the end of the aeration tanks. Thus, their emissions rates were not calculated. Emissions from the aeration tanks were based on the models discussed in Section 5.2.3. Weir formulas were used to estimate emissions from the weirs.

Secondary Clarifiers

VOCs will be emitted from the surfaces of the secondary clarifiers and from the effluent weirs. The emissions from the clarifier surfaces were included because these basins will not be covered, and the wind action on the surfaces will increase volatilization. The procedure described in Section 5.2.1 was used to calculate emissions from the clarifier surface. Weir formulas were used to calculate emissions from the weirs.

Disinfection Basins

The emissions from the disinfection basins were calculated using the procedure described in Section 5.2.1 for emissions from tank surfaces. Emissions from the weirs at the end of the disinfection basins were not calculated. It was observed that VOCs were almost completely eliminated at the end of the disinfection basins. In fact, emissions from the disinfection basins could have been disregarded because the concentration of VOCs after the secondary clarifiers was so low.

5.4.3 DATA FOR EMISSIONS SOURCES

Three discrete types of data are required for the treatment systems, depending on whether the systems are being modeled as a weir, a quiescent liquid, or an aeration tank. Pertinent data required for calculating emissions are provided in Tables 5.4.3-1 and 5.4.3-2.

5.5 SCENARIOS EVALUATED FOR EMISSION CALCULATIONS

The Deer Island upgrade is being designed to accommodate a variety of load and flow conditions. Several distinct flow regimes exist, encompassing storm and non-storm flows in low-flow and high-flow seasons. The data assembled from the wastewater sampling programs have been split into groups consisting of minimum-, maximum-, and average-day loadings. Finally, the orientation of proposed treatment units may change with the overall treatment process. Since the number of potential scenarios derived from all possible combinations of these variables becomes unmanageable with respect to emission calculation only reasonable worst-case scenarios were evaluated.

As discussed in Section 3, the evaluation of emissions must consider two aspects of the proposed system: the expected increase in VOC emissions (determined on an annual basis); and the maximum expected ambient impacts of potentially toxic releases from the facility (determined on a 24-h basis). Because of these two main aspects of concern, all scenarios containing minimum pollutant mass loadings were removed from further consideration.

TABLE 5.4.3-1
Treatment System Physical Data

Unit	No. of units	Overall Area, m^2	Depth, m	Weir Length, m	Tailwater Depth, m
Centrifugal Grit	16			43.6	3.6
Primary Clarifier	4				
Splitter	1			24.4	3.4
Weir	20			1120.0	0.5
Aeration Tank	4	37972	23.5		
Splitter	1		32.0	3.6	
Weir	4			274.3	3.6
Secondary Clarifier	4	56013	30		
Weir	4			8000.0	0.5
Disinfection	1	11576		13	

TABLE 5.4.3-2
Treatment System Operating Characteristics for Proposed Deer Island Facilities

Unit	Flow Condition: Average Low GW	Average High GW	Minimum	Maximum	Max+Storm
Centrifugal Grit					
flow, m^3/s	12.27	16.04	10.0	26.2	40.0
drop height, m	0.62	0.62	0.6	0.68	0.78
Primary Clarifier					
Splitter					
flow, m^3/s	17.09	26.73	14.02	42.07	55.65
drop height, m	0.88	0.71	0.89	0.66	0.42
Weir					
flow, m^3/s	17.09	26.73	14.02	42.07	55.65
drop height, m	0.78	0.62	0.83	0.41	0.23
Aeration Tank					
Splitter					
flow, m^3/s	22.79	35.54	16.12	56.09	69.36
drop height, m	1.25	0.91	1.25	1.29	0.51
Basin					
flow, m^3/s	22.79	35.54	16.12	56.09	69.36
biomass, g/l	2.0	2.0	2.0	2.0	2.0
air flow, m^3/s	62.96	62.98	131.73	136.41	141.11
K_La, 1/day	85	85	164	172	179
oxygen flow, m^3/s	1.37	1.37	2.86	2.96	3.07
K_La , 1/day	113	113	218	229	239
Weir					
flow, m^3/s	22.79	35.54	16.12	56.09	69.36
drop height, m	0.88	0.69	0.89	0.59	0.40
Secondary Clarifier					
Weir					
flow, m3/s	17.09	26.73	14.02	42.07	47.32
drop height, m	0.73	0.53	0.79	0.33	0.15

Two flow regimes exist under average conditions: average flow during low groundwater levels, and average flow during high groundwater levels. The level of the groundwater influences the amount of clean water infiltrating the collector system and thus impacts the volume of water that must be treated. The actual load of contaminants in the influent, in terms of pounds per day, will not change between the two groundwater level regimes, but the increased infiltration during high groundwater seasons will reduce the pollutant concentrations, shorten the unit process detention times, and increase the overflow rate in the treatment system. All of these conditions will affect the rate at which pollutants are emitted.

An estimate of the annual emissions from the treatment system was obtained by performing emission calculations for the two average-flow conditions with average pollutant loadings. On the average, a low groundwater level exists eight months out of the year; a high groundwater level exists the remaining four months. Annual emissions were calculated for each of the two groundwater conditions. The overall annual emission rate for each individual constituent was then determined by calculating a weighted average of the two rates based on the amount of time each groundwater condition occurs during the year. This weighted average produces an annual average flow rate of 480 mgd, compared to 380 mgd and 670 mgd for the low and high groundwater level conditions, respectively. The total VOC emission rate was estimated using the relationship of VOCs to the sum of individual constituents as described in Section 4.4.

Maximum short-term emission rates were calculated for several different flow scenarios using maximum constituent mass loading rates. No other average conditions, other than those discussed above, were subjected to the emission calculation procedures. The minimum wastewater flow was considered because long detentions and large drops over the weirs could yield high emission rates for volatile constituents with low biodegradation rates. Minimum-flow rates would also allow more time for the constituent to escape to the atmosphere from the basins.

The maximum flow was selected to ensure that the scenario representing the maximum short-term emission rate had been analyzed. The constituent loadings added by storm runoff were also included in a calculation using normal maximum loadings at maximum normal-flow plus maximum storm water flow. Identification of these three scenarios for emission calculations was expected to yield a larger short-term emission rate than any other conceivable situation. Upon reviewing the results of each emission scenario, those expected to produce the greatest ambient impacts were subjected to the air pollutant dispersion modeling analysis described in Section 7.

5.6 RESULTS OF EMISSION CALCULATIONS

Emissions were calculated for existing and proposed facilities at Nut and Deer Islands for the scenarios described in Section 5.5 using treatment trains consisting of air or oxygen activated sludge. Emissions from the existing treatment systems on Deer and Nut Islands were also calculated. The output generated by the computer program used provided an annual emission total for each constituent, by treatment unit, as well as the individual maximum emission rate for each constituent across the entire system. These rates represent emissions prior to control. The existing facilities on Deer Island were estimated to emit a total of 40 tons/yr

of PPL/HSL constituents; existing Nut Island facilities were estimated to emit 7 tons/yr.

The conditions representing baseline were established for the Deer Island treatment units and the Nut Island treatment units to define the major source status of the existing treatment systems. The status of the three headworks was not determined since these systems have already received construction permits. After the baseline conditions were established, the emission rates of the individual constituents in the wastewater were calculated using the procedures described in Section 5.5 of this Appendix. Based on these procedures and the data presented in Sections 4 and 5, the baseline Deer Island facilities emit a total of 40 tons/yr of individual constituents and the Nut Island facilities emit a total of 7 tons/yr.

All of the individual constituents for which emission rates were determined are considered VOCs. The total VOC emission rate, however, will exceed the sum of emission rates for the individual constituents because there are many other organic compounds in the wastewater that can be volatilized. Most of these VOCs will not be potentially toxic, but they will contribute to the total baseline emission rate (as well as the projected emission increases) and thus will affect the decisions regarding preconstruction approval. At this point, limited data exist on total VOCs and their relationship to the individual constituents present in liquid and air streams.

Air emissions data generated at the three headworks treatment facilities were examined to estimate the total VOC emission rate. Unfortunately, the data were inconclusive with respect to any clear relationship between individual constituents and total VOCs. In reviewing the data generated for total VOCs and individual constituents, the only conclusion derived was that the ratio of VOCs and the sum of individual constituents were between 20 and 50. No statistical correlation was found, however, between the two parameters. Nevertheless, the data provided an indication that the existing facilities on Deer and Nut Islands should be considered as major existing sources of VOCs, with emissions ranging between 810 and 2000 tons/yr at Deer Island and between 140 and 350 tons/yr at Nut Island. Additional study is needed to more accurately estimate the total VOC load from existing and proposed facilities.

The results obtained for the proposed facilities at average flow and load conditions are presented in Table 5.6-1 for the air system and in Table 5.6-2 for the oxygen system. The tables give the individual annual uncontrolled emission rates for all constituents by source and in total. Comparison of the tables shows that the annual uncontrolled emissions from the oxygen system will be slightly less than from the air system. This is because the volume of oxygen used in the aeration system is only about one-fortieth of that for air.

The maximum short-term uncontrolled emission rates for each individual constituent, by source, are provided in Tables 5.6-3 and 5.6-4 for the air and oxygen systems, respectively. Like the annual rates, the short-term emission rates show that the activated sludge system with oxygen generates fewer emissions than the system with air for aeration. These short-term emission rates (after a control factor has been applied) are calculated for comparison with AALs.

The distribution of emissions by treatment unit indicates that a majority of the releases occur prior to the aeration basin. As discussed earlier, the major reason for this

TABLE 5.6-1
Annual Uncontrolled Emission Estimates For Individual Constituents Released From The Proposed Deer and Nut Island Treatment Facilities -- Air Feed System at Deer Island. (tons/yr)

	Nut Island			Deer Island				
Constituent	Distr Chan.	Grit Weir	Total	Primary Area	Aeration Area	Final Clarifier	Disinfec-tion	Total
Benzene	0.00	0.01	0.01	0.94	0.37	0.00	0.00	1.31
Chloroform	0.00	0.02	0.02	1.29	1.17	0.04	0.00	2.50
Ethylbenzene	0.00	0.03	0.03	1.96	1.41	0.00	0.00	3.37
Methylene chloride	0.00	0.13	0.13	7.64	3.27	0.00	0.00	10.91
Tetrachloroethene	0.00	0.06	0.06	3.37	1.48	0.00	0.00	4.85
Toluene	0.00	0.05	0.05	4.12	1.90	0.00	0.00	6.02
Trans-dichloroethene (1,2)	0.00	0.03	0.03	2.02	0.90	0.00	0.00	2.92
1,1,1-Trichloroethane	0.00	0.04	0.04	2.97	4.29	0.02	0.00	7.28
Trichloroethene	0.00	0.04	0.04	2.46	2.65	0.00	0.00	5.11
Trichlorofluoromethane	0.00	0.05	0.05	2.70	1.40	0.00	0.00	4.10
Styrene	0.00	0.04	0.04	1.63	1.46	0.04	0.00	3.13
Acetone	0.00	0.01	0.01	0.88	0.72	0.03	0.00	1.63
2-Butanone	0.00	0.00	0.00	0.18	0.09	0.00	0.00	0.27
Total xylenes	0.00	0.08	0.08	4.66	1.81	0.00	0.00	6.47
1,1,2,2-Tetrachloroethane	0.00	0.00	0.00	1.78	0.87	0.06	0.01	2.72
Methyl mercaptan	0.00	0.09	0.09	3.67	3.32	0.12	0.01	7.12
Bromomethane	0.00	0.08	0.08	4.44	5.00	0.06	0.00	9.50
2-Propanone, 1-fluoro	0.00	0.00	0.00	1.14	1.90	0.02	0.00	3.06
Carbon disulfide	0.00	0.04	0.04	1.45	1.95	0.01	0.00	3.41
2-Butanone, 3-methoxy, 3-methyl	0.00	0.00	0.00	0.53	0.91	0.03	0.00	1.47
Ethyl ether	0.00	0.00	0.00	0.10	0.22	0.05	0.01	0.38
Phenol	0.00	0.00	0.00	0.03	0.06	0.01	0.00	0.10
Naphthalene	0.00	0.10	0.10	2.27	0.91	0.00	0.00	3.18
Chlorobenzene	0.00	0.04	0.04	2.44	0.92	0.00	0.00	3.36
o-Cresol	0.00	0.00	0.00	0.54	0.19	0.00	0.00	0.73
p-Cresol	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
1,2-Dichlorobenzene	0.00	0.10	0.10	3.27	2.72	0.12	0.01	6.12
Benzenamine	0.00	0.00	0.00	1.16	0.97	0.06	0.00	2.19
Hexone (MIBK)	0.00	0.00	0.00	0.07	0.11	0.07	0.01	0.26
Benzyl alcohol	0.00	0.00	0.00	0.08	0.06	0.02	0.00	0.16
Pentane, 3-meth, 2,2,4-trimethyl	0.00	0.03	0.03	1.09	0.90	0.04	0.00	2.03
Dimethyl disulfide	0.00	0.00	0.00	0.38	0.32	0.02	0.00	0.72
Dimethyl sulfide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	0.01	1.05	1.06	61.25	44.24	0.81	0.09	106.39

TABLE 5.6-2
Annual Uncontrolled Emission Estimates For Individual Constituents Released From The Proposed Deer and Nut Island Treatment Facilities -- Oxygen Feed System. (tons/yr)

	Nut Island			Deer Island				
Constituent	Distr Chan	Grit Weir	Total	Primary Area	Aeration Area	Final Clarifier	Disinfec-tion	Total
Benzene	0.00	0.01	0.01	0.94	0.36	0.00	0.00	1.30
Chloroform	0.00	0.02	0.02	1.29	0.95	0.05	0.00	2.29
Ethylbenzene	0.00	0.03	0.03	1.96	1.55	0.00	0.00	3.51
Methylene chloride	0.00	0.13	0.13	7.64	2.87	0.00	0.00	10.51
Tetrachloroethene	0.00	0.06	0.06	3.37	1.27	0.00	0.00	4.64
Toluene	0.00	0.05	0.05	4.12	1.99	0.00	0.00	6.11
Trans-dichloroethene (1,2)	0.00	0.03	0.03	2.02	0.72	0.00	0.00	2.74
1,1,1-Trichloroethane	0.00	0.04	0.04	2.97	2.34	0.12	0.01	5.44
Trichloroethene	0.00	0.04	0.04	2.46	2.86	0.00	0.00	5.32
Trichlorofluoromethane	0.00	0.05	0.05	2.70	0.98	0.00	0.00	3.68
Styrene	0.00	0.04	0.04	2.21	1.63	0.09	0.01	3.94
Acetone	0.00	0.01	0.01	0.40	0.22	0.00	0.00	0.62
2-Butanone	0.00	0.00	0.00	0.10	0.05	0.00	0.00	0.15
Total xylenes	0.00	0.08	0.08	6.28	2.33	0.00	0.00	8.61
1,1,2,2-Tetrachloroethane	0.00	0.00	0.00	0.18	0.23	0.08	0.01	0.50
Methyl mercaptan	0.00	0.09	0.09	4.90	3.62	0.20	0.01	8.73
Bromomethane	0.00	0.08	0.08	4.29	3.28	0.14	0.01	7.72
2-Propanone, 1-fluoro	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.06
Carbon disulfide	0.00	0.04	0.04	1.95	1.54	0.08	0.01	3.58
2-Butanone, 3-methoxy, 3-methyl	0.00	0.00	0.00	0.03	0.03	0.03	0.01	0.10
Ethyl ether	0.00	0.00	0.00	0.12	0.16	0.06	0.01	0.35
Phenol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Naphthalene	0.00	0.10	0.10	3.08	1.18	0.00	0.00	4.26
Chlorobenzene	0.00	0.04	0.04	2.17	0.81	0.00	0.00	2.98
o-Cresol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
p-Cresol	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
1,2-Dichlorobenzene	0.00	0.10	0.10	4.43	3.42	0.19	0.01	8.05
Benzenamine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hexone (MIBK)	0.00	0.00	0.00	0.09	0.11	0.09	0.02	0.31
Benzyl alcohol	0.00	0.00	0.00	0.08	.05	0.00	0.00	0.13
Pentane, 3-meth, 2,2,4-trimethyl	0.00	0.03	0.03	1.44	1.11	0.06	.00	2.61
Dimethyl disulfide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dimethyl sulfide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	0.01	1.05	1.06	61.25	35.68	1.20	0.11	98.25

Table 5.6-3
Maximum Short-term Uncontrolled Emission Estimates for Individual Constituents Under Various Flow and Maximum Load Conditions on Deer and Nut Islands -- Air Feed System. (lb/day)

Constituent	Nut Island Max Flow	Deer Island Min Flow	Deer Island Max Flow	Deer Island Max Strm Flow
Benzene	0.23	11.32	8.44	13.22
Chloroform	0.31	32.50	24.42	30.14
Ethylbenzene	0.55	43.66	39.79	35.60
Methylene chloride	5.23	182.34	142.37	96.04
Tetrachloroethene	1.29	71.70	55.92	71.13
Toluene	8.08	93.15	73.15	57.07
Trans-dichloroethene (1,2)	0.64	31.10	25.41	21.30
1,1,1-Trichloroethane	0.76	80.74	79.31	88.65
Trichloroethene	0.98	68.55	68.22	81.84
Trichlorofluoromethane	0.51	34.81	29.95	45.72
Styrene	0.50	41.77	31.44	40.84
Acetone	0.21	11.46	7.34	5.74
2-Butanone	0.08	2.20	1.41	1.20
Total xylenes	1.81	139.08	102.22	93.93
1,1,2,2-Tetrachloroethane	0.03	8.42	3.89	2.94
Methyl mercaptan	1.02	107.18	80.47	98.27
Bromomrethane	1.36	97.16	101.17	93.76
2-Propanone, 1-fluoro	0.01	0.34	0.32	0.21
Carbon disulfide	0.49	43.62	42.83	67.61
2-Butanone, 3-methoxy, 3-methyl	0.01	1.04	0.45	0.57
Ethyl ether	0.03	5.56	2.57	3.24
Phenol	0.00	0.05	0.03	0.02
Naphthalene	2.11	64.86	4.70	29.56
Chlorobenzene	0.50	28.39	20.82	19.08
o-Cresol	0.00	0.05	0.03	0.03
p-Cresol	0.00	0.05	0.03	0.03
1,2-Dichlorobenzene	1.99	94.37	67.06	43.68
Benzenamine	0.00	0.05	0.03	0.03
Hexone (MIBK)	0.03	4.32	1.88	2.05
Benzyl alcohol	0.03	1.51	0.97	0.89
Pentane, 3-meth, 2,2,4-trimethyl	0.33	22.22	15.80	20.26
Dimethyl disulfide	0.00	0.03	0.01	0.02
Dimethyl sulfide	0.00	0.10	0.05	0.04
TOTAL	29.12	1323.70	1032.53	1064.73

Table 5.6-4
Maximum Uncontrolled Short-term Emission Estimates for Individual Constituents Under Various Flow and Maximum Load Conditions on Deer and Nut Islands -- Oxygen Feed System. (lb/day)

	Nut Island	Deer Island		
Constituent	Max Flow	Min Flow	Max Flow	Max Strm Flow
Benzene	0.23	11.28	8.37	12.98
Chloroform	0.31	28.81	20.65	22.51
Ethylbenzene	0.55	45.12	42.13	38.59
Methylene chloride	5.23	173.39	128.66	79.35
Tetrachloroethene	1.29	67.67	49.13	55.32
Toluene	8.08	94.80	75.89	60.85
Trans-dichloroethene (1,2)	0.64	28.75	21.27	15.14
1,1,1-Trichloroethane	0.76	66.39	47.66	38.66
Trichloroethene	0.98	70.19	70.81	85.98
Trichlorofluoromethane	0.51	30.68	22.74	27.67
Styrene	0.50	37.02	26.59	30.49
Acetone	0.21	11.40	7.27	5.64
2-Butanone	0.08	2.19	1.40	1.18
Total xylenes	1.81	138.14	100.60	90.85
1,1,2,2-Tetrachloroethane	0.03	5.02	2.57	1.72
Methyl mercaptan	1.02	74.66	53.49	57.68
Bromomethane	1.36	86.30	64.71	43.70
2-Propanone, 1-fluoro	0.01	0.27	0.27	0.17
Carbon disulfide	0.49	35.87	25.73	29.48
2-Butanone, 3-methoxy, 3-methyl	0.01	0.85	0.39	0.46
Ethyl ether	0.03	3.31	1.70	1.89
Phenol	0.00	0.05	0.03	0.02
Naphthalene	2.11	64.62	46.60	29.04
Chlorobenzene	0.50	28.20	20.50	18.47
o-Cresol	0.00	0.05	0.03	0.03
p-Cresol	0.00	0.05	0.03	0.03
1,2-Dichlorobenzene	1.99	89.41	63.01	39.09
Benzenamine	0.00	0.05	0.03	0.03
Hexone (MIBK)	0.03	3.52	1.60	1.68
Benzyl alcohol	0.03	1.50	0.96	0.88
Pentane, 3-meth, 2,2,4-trimethyl	0.33	21.05	14.85	18.13
Dimethyl disulfide	0.00	0.03	0.01	0.02
Dimethyl sulfide	0.00	0.10	0.05	0.04
TOTAL	29.12	1220.77	919.75	807.77

is turbulence as wastewater flows over weirs.

The proposed treatment facility at Deer Island will include covers to prevent uncontrolled release of air pollutants. The covers will be installed on all portions of the facility between and including the centrifugal grit chambers and the aeration tank effluent weirs. The emissions from each of these treatment systems will be collected and delivered to an odor/VOC control system before discharge to the atmosphere. Several independent systems will be operated for control of offgas streams from various treatment units. Details on the control system are provided in Section 6.

For the purpose of providing a conservative estimate, a control efficiency of 85 percent through the emission control system has been assumed for all constituents except the reduced sulfur species; 95 percent control has been assumed for these constituents. Based on these removal efficiencies, the annual controlled emission rate is 15.3 tons/yr of individual constituents for the air system and 14.7 tons/yr of individual constituents for the oxygen system. Table 5.6-5 presents the estimated annual release rate for each constituent after control from the proposed facilities and from the existing facilities. The maximum short-term controlled release rates for all other scenarios are provided in Table 5.6-6 for the air system and Table 5.6-7 for the oxygen system.

As discussed in Section 3, the level of control implemented for the proposed system is dependent on the magnitude of VOC emission increases above a baseline emission rate. Based on the relationship discussed between VOCs and individual constituents, the VOC baseline emission rate is estimated to be between 810 and 2000 tons/yr for Deer Island and between 140 and 350 tons/yr for Nut Island. Applying this same relationship (that total VOCs are equal to 20 to 50 times the sum of the individual constituents) yields an estimated controlled VOC emission rate of between 306 and 766 tons/yr for the proposed air system on Deer Island, between 293 and 733 tons/yr for the proposed oxygen system on Deer Island, and between 21.0 and 53.0 tons/yr for the proposed facilities on Nut Island.

Because comparison of proposed to existing annual VOC emissions yields a net reduction from Deer Island and Nut Island baseline levels, the control systems required for both Deer and Nut Island facilities must represent BACT. Comparison of the average existing and maximum short-term emission rates provided in Tables 5.6-6 and 5.6-7 shows that the maximum short-term emission rate of each individual constituent released by the proposed system, with a few minor exceptions, is also less than the individual rates at baseline conditions.

Although the uncontrolled emissions are greater from the proposed facilities than from the existing facilities, the need to apply BACT to the proposed facilities produces a net reduction in actual emissions for both total VOCs and most individual constituents. This indicates that regulatory requirements are met with the use of BACT as opposed to LAER, and that the VOC emissions from the proposed facilities are not required to be offset. Final selection of the odor/VOC control system, however, is also dependent on the ambient impact of the individual consitutents. This aspect is discussed in Section 7

Table 5.6-5
Comparison of Annual Controlled Constituent Emission Estimates for the Existing and Proposed Treatment Systems on Deer and Nut Islands. (tons/yr)

Constituent	Deer Island Existing	Deer Island Proposed oxygen	Deer Island Proposed air	Nut Island Existing	Nut Island Proposed
Benzene	0.64	0.20	0.20	0.09	0.01
Chloroform	0.91	0.39	0.41	0.13	0.02
Ethylbenzene	1.38	0.53	0.50	0.25	0.03
Methylene chloride	5.16	1.58	1.64	0.80	0.13
Tetrachloroethene	2.26	0.70	0.73	0.37	0.06
Toluene	3.10	0.92	0.90	0.30	0.05
Trans-dichloroethene (1,2)	1.37	0.41	0.44	0.23	0.03
1,1,1-Trichloroethane	2.15	0.92	1.11	0.27	0.04
Trichloroethene	1.68	0.80	0.77	0.26	0.04
Trichlorofluoromethane	1.97	0.55	0.61	0.30	0.05
Styrene	1.47	0.64	0.71	0.23	0.04
Acetone	0.43	0.13	0.09	0.10	0.01
2-Butanone	0.00	0.02	0.02	0.08	0.00
Total xylenes	4.65	1.29	1.30	0.46	0.08
1,1,2,2-Tetrachloroethane	0.14	0.13	0.18	0.08	0.00
Methyl mercaptan	2.84	0.59	0.63	0.60	0.09
Bromomethane	2.80	1.30	1.50	0.48	0.08
2-Propanone, 1-fluoro	0.02	0.07	0.03	0.03	0.00
Carbon disulfide	1.25	0.24	0.25	0.22	0.04
-Butanone, 3-methoxy, 3-methyl	0.02	0.06	0.04	0.01	0.00
Ethyl ether	0.09	0.10	0.12	0.02	0.00
Phenol	0.00	0.02	0.00	0.04	0.00
Naphthalene	1.29	0.64	0.64	0.58	0.10
Chlorobenzene	1.32	0.45	0.45	0.22	0.04
o-Cresol	0.00	0.00	0.00	0.00	0.00
p-Cresol	0.00	0.00	0.00	0.05	0.00
1,2-Dichlorobenzene	2.36	1.31	1.41	0.60	0.10
Benzenamine	0.00	0.07	0.00	0.00	0.00
Hexone (MIBK)	0.08	0.11	0.14	0.02	0.00
Benzyl alcohol	0.08	0.04	0.02	0.04	0.00
Pentane, 3-meth, 2,2,4-trimethyl	0.81	0.43	0.46	0.16	0.03
Dimethyl disulfide	0.00	0.02	0.00	0.00	0.00
Dimethyl sulfide)	0.00	0.00	0.00	0.00	0.00
TOTAL	40.40	14.66	15.31	7.01	1.06

Table 5.6-6
Short-term Controlled Constituent Emission Estimates Under Various Flow and Maximum Load Conditions For the Existing and Proposed Treatment Systems on Deer and Nut Islands -- Air System. (lb/day)

	Nut Island		Deer Island			
Constituent	Existing Avg	Proposed Max Flow	Existing Avg	Proposed Min Flow	Proposed Max Flow	Proposed Max Strm
Benzene	0.50	0.23	3.53	1.70	1.27	1.98
Chloroform	0.71	0.31	4.98	5.09	3.98	4.92
Ethylbenzene	1.35	0.55	7.58	6.55	5.97	5.34
Methylene chloride	4.36	5.23	28.27	27.35	21.57	14.65
Tetrachloroethene	2.02	1.29	12.40	10.76	8.39	10.67
Toluene	1.64	8.08	17.01	13.97	10.97	8.56
Trans-dichloroethene (1,2)	1.28	0.64	7.50	4.66	3.81	3.19
1,1,1-Trichloroethane	1.46	0.76	11.78	12.12	12.05	13.48
Trichloroethene	1.45	0.98	9.21	10.28	10.23	12.28
Trichlorofluoromethane	1.65	0.51	10.82	5.22	4.49	6.86
Styrene	1.25	0.50	8.03	6.54	5.13	6.67
Acetone	0.53	0.21	2.37	1.72	1.10	0.86
2-Butanone	0.45	0.08	0.47	0.33	0.21	0.18
Total xylenes	2.52	1.81	25.46	20.86	15.33	14.09
1,1,2,2-Tetrachloroethane	0.45	0.03	0.78	2.06	0.86	0.71
Methyl mercaptan	3.29	1.02	15.58	3.73	3.15	3.86
Bromomethane	2.61	1.36	15.35	14.57	15.22	14.11
2-Propanone, 1-fluoro	0.18	0.01	0.13	0.14	0.10	0.08
Carbon disulfide	1.21	0.49	6.86	2.18	2.23	3.53
2-Butanone, 3-methoxy, 3-methyl	0.04	0.01	0.13	0.43	0.15	0.22
Ethyl ether	0.11	0.03	0.47	1.36	0.57	0.78
Phenol	0.24	0.00	0.01	0.01	0.00	0.00
Naphthalene	3.18	2.11	7.07	9.73	7.10	4.43
Chlorobenzene	1.23	0.50	7.23	4.26	3.12	2.86
o-Cresol	0.00	0.00	0.01	0.01	0.00	0.00
p-Cresol	0.26	0.00	0.01	0.01	0.00	0.00
1,2-Dichlorobenzene	3.27	1.99	12.95	15.44	11.26	7.36
Benzenamine	0.01	0.00	0.01	0.01	0.00	0.00
Hexone (MIBK)	0.11	0.03	0.45	1.78	0.61	0.80
Benzyl alcohol	0.19	0.03	0.43	0.23	0.15	0.13
Pentane, 3-meth, 2,2,4-trimethyl	0.88	0.33	4.46	3.63	2.65	3.42
Dimethyl disulfide	0.00	0.00	0.00	0.01	0.00	0.00
Dimethyl sulfide	0.00	0.00	0.01	0.03	0.01	0.01
TOTAL	38.43	29.12	221.37	186.77	151.71	146.07

Table 5.6-7
Actual Short-Term Controlled Constituent Emission Estimates Under Various Flow and Maximum Load Conditions For the Existing and Proposed Treatment Systems on Deer and Nut Islands -- Oxygen System. (lb/day)

	Nut Island		Deer Island			
Constituent	Existing Avg	Proposed Max Flow	Existing Avg	Proposed Min Flow	Proposed Max Flow	Proposed Max Strm
Benzene	0.50	0.23	3.53	1.69	1.26	1.95
Chloroform	0.71	0.31	4.98	4.80	3.51	3.87
Ethylbenzene	1.35	0.55	7.58	6.77	6.32	5.79
Methylene chloride	4.36	5.23	28.27	26.01	19.57	12.21
Tetrachloroethene	2.02	1.29	12.40	10.15	7.37	8.30
Toluene	1.64	8.08	17.01	14.22	11.38	9.13
Trans-dichloroethene (1,2)	1.28	0.64	7.50	4.31	3.19	2.27
1,1,1-Trichloroethane	1.46	0.76	11.78	10.92	8.05	6.58
Trichloroethene	1.45	0.98	9.21	10.53	10.62	12.90
Trichlorofluoromethane	1.65	0.51	10.82	4.60	3.41	4.15
Styrene	1.25	0.50	8.03	6.16	4.52	5.24
Acetone	0.53	0.21	2.37	1.71	1.09	0.85
2-Butanone	0.45	0.08	0.47	0.33	0.21	0.18
Total xylenes	2.52	1.81	25.46	20.72	15.09	13.63
1,1,2,2-Tetrachloroethane	0.45	0.03	0.78	1.64	0.67	0.53
Methyl mercaptan	3.29	1.02	15.58	6.50	4.92	5.47
Bromomethane	2.61	1.36	15.35	13.78	10.73	7.31
2-Propanone, 1-fluoro	0.18	0.01	0.13	0.13	0.10	0.08
Carbon disulfide	1.21	0.49	6.86	2.38	1.83	2.14
2-Butanone, 3-methoxy, 3-methyl	0.04	0.01	0.13	0.40	0.14	0.20
Ethyl ether	0.11	0.03	0.47	1.08	0.44	0.58
Phenol	0.24	0.00	0.01	0.01	0.00	0.00
Naphthalene	3.18	2.11	7.07	9.69	0.70	4.36
Chlorobenzene	1.23	0.50	7.23	4.23	3.07	2.77
o-Cresol	0.00	0.00	0.01	0.01	0.00	0.00
p-Cresol	0.26	0.00	0.01	0.01	0.00	0.00
1,2-Dichlorobenzene	3.27	1.99	12.95	15.00	10.75	6.73
Benzenamine	0.01	0.00	0.01	0.01	0.00	0.00
Hexone (MIBK)	0.11	0.03	0.45	1.67	0.57	0.74
Benzyl alcohol	0.19	0.03	0.43	0.23	0.14	0.13
Pentane, 3-meth, 2,2,4-trimethyl	0.88	0.33	4.46	3.53	2.53	3.12
Dimethyl disulfide	0.00	0.00	0.00	0.01	0.00	0.00
Dimethyl sulfide	0.00	0.00	0.01	0.01	0.01	0.01
TOTAL	38.43	29.12	221.37	183.22	132.21	121.24

5.7 SCENARIOS SELECTED FOR AMBIENT IMPACT ASSESSMENT

The oxygen system results presented in the preceding section indicate that the scenario using maximum load and minimum flow conditions produces the greatest short-term emission rate for all but two constituents (benzene and trichloroethene). Review of the detailed emission results indicated the benzene will be released in greater amounts during storm flows from the grit chamber and trichloroethene from the aeration tanks. Maximum ambient air impacts were estimated by performing dispersion calculations only for the maximum load, minimum flow scenario. Using the emissions for benzene and trichloroethene during maximum flow, rather than the emissions during storm flow, underestimates the ambient impact of these compounds by about 15 percent for benzene and 23 percent for trichloroethene. But as shown later in this report (Table 7.6.1), the worst-case 24-hour concentration for benzene is only 6 percent of the AAL. For trichloroethene, the ambient concentration would be less than 2 percent of the AAL, so the ambient concentrations of benzene and trichloroethene would be well below the AALs.

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6.0 EVALUATION OF SYSTEMS FOR CONTROLLING EMISSIONS

This section reviews available technologies for both odor and VOC abatement and identifies technologies appropriate for use at Deer and Nut Islands. Technologies that should be subjected to a detailed analysis for incorporation in the final design are identified, and include pollutant removal or control from the wastewater before the pollutants are released to the atmosphere, and collection and control of air streams.

6.1 CONTROL TECHNOLOGIES FOR LIQUID STREAMS

The potential for release of odors from wastewater can be decreased by treating the liquid stream. Some of the methods available include chemical oxidation, raising the oxidation/reduction potential, and pH control.

Chemical oxidation is obtained by adding chlorine, ozone, hydrogen peroxide, or potassium permanganate to wastewater. These chemicals can inhibit the growth of bacteria that produce odorous compounds and can also oxidize the compounds. Chlorine, for example, can oxidize sulfide to sulfate.

Oxidation/reduction control can be be achieved by adding dissolved oxygen or nitrate to wastewater. With oxygen or nitrate present, sulfide will not be produced.

Lime or caustic soda can be added to wastewater to raise the pH high enough (pH 8 or more) so that hydrogen sulfide will not be released.

These systems have been used in wastewater systems and treatment plants. However, to be conservative, in analyses of emissions from the Deer Island plant and the Nut Island headworks, the use of chemicals to decrease the potential for odors was not considered. This means that the equipment to control odors would be adequate without addition of chemicals.

6.2 CONTROL TECHNOLOGIES FOR AIR STREAMS

Odor-producing compounds and VOCs in air streams are controlled by collecting the air streams and treating them before release to the atmosphere. Available treatment technologies include: ozonation, wet scrubbing with a mist chamber, wet scrubbing with a packed tower, carbon adsorption, incineration, and condensation. Some processes are applicable for both odor and VOC control; some are applicable for either one or the other, but not for both.

6.2.1 OZONATION

In an ozonation system, odorous air is contacted with ozone in a long, baffled chamber to promote mixing and oxidation of the odorous compounds. A typical ozonation system produces ozone from clean dry air and diffuses the ozone into a contact chamber where the ozone oxidizes the odorous compounds.

To date, the use of ozone systems has been limited to odor control, rather than VOC control. Based on past operating experience, ozone systems have not proven to be effective for odor control. Ozone manufacturers originally promoted the use of ozone in odor control systems because ozone rapidly oxidizes many odorous compounds in the aqueous phase. In the gaseous phase, however, ozone systems oxidize only a small portion of the odorous compounds present. Instead of oxidizing the others, ozone simply masks their odors. When the exhaust from an ozone system is dispersed from the source, the ozone can degrade to oxygen and the original odors will reappear. If too much ozone is added, high levels of unreacted ozone in the exhaust can promote odor complaints because ozone has a sharp, acrid smell. It may be a health hazard, since ozone is toxic at concentrations above 1 ppm.

6.2.2 WET SCRUBBING

Control of gaseous contaminants can be accomplished by liquid scrubbing. In this method, a contaminated gas stream is brought into contact with a scrubbing liquid, allowing contaminant gases to be absorbed into the liquid. The cleaned gas is then separated from the contaminated liquid, which may be collected and treated. The rate of mass transfer of the contaminating gas into the scrubbing liquid is proportional to the gas-liquid interface surface area. Scrubbing units are therefore designed to provide large liquid surface areas. Typical unit designs include packed towers, spray towers, mist chambers, and venturi absorbers.

The efficiency of wet scrubbers can be enhanced by using caustic soda. The caustic soda increases the pH of the solution to increase solubility of hydrogen sulfide.

Scrubbing is very effective for removing odors because of the high solubility of hydrogen sulfide in high-pH solutions. Scrubbing is less effective, however, in removing VOCs. VOCs are generally less soluble, and, because of their very low concentration in exhaust air streams from wastewater treatment processes, significant mass transfer of the organics from the gas to a scrubber liquid is difficult to obtain. So, for both odor and VOC control, a wet scrubber would require a downstream polishing component to control the organic component.

Mist Chambers

One of the most widely used configurations for wet scrubbing are mist chambers. (See Figure 6.2.2-1.)

Mist chambers produce a fine aerosol mist or fog through which odorous gases are passed. Compressed air and the oxidizing/neutralizing liquid are introduced through nozzles designed to produce a very fine mist (5 to 10 microns), which produces a very large surface area for transfer between phases. The treated air exits from the top of the chamber, and the liquid drains from the bottom. With a mist chamber, there is no recirculation of caustic soda solution.

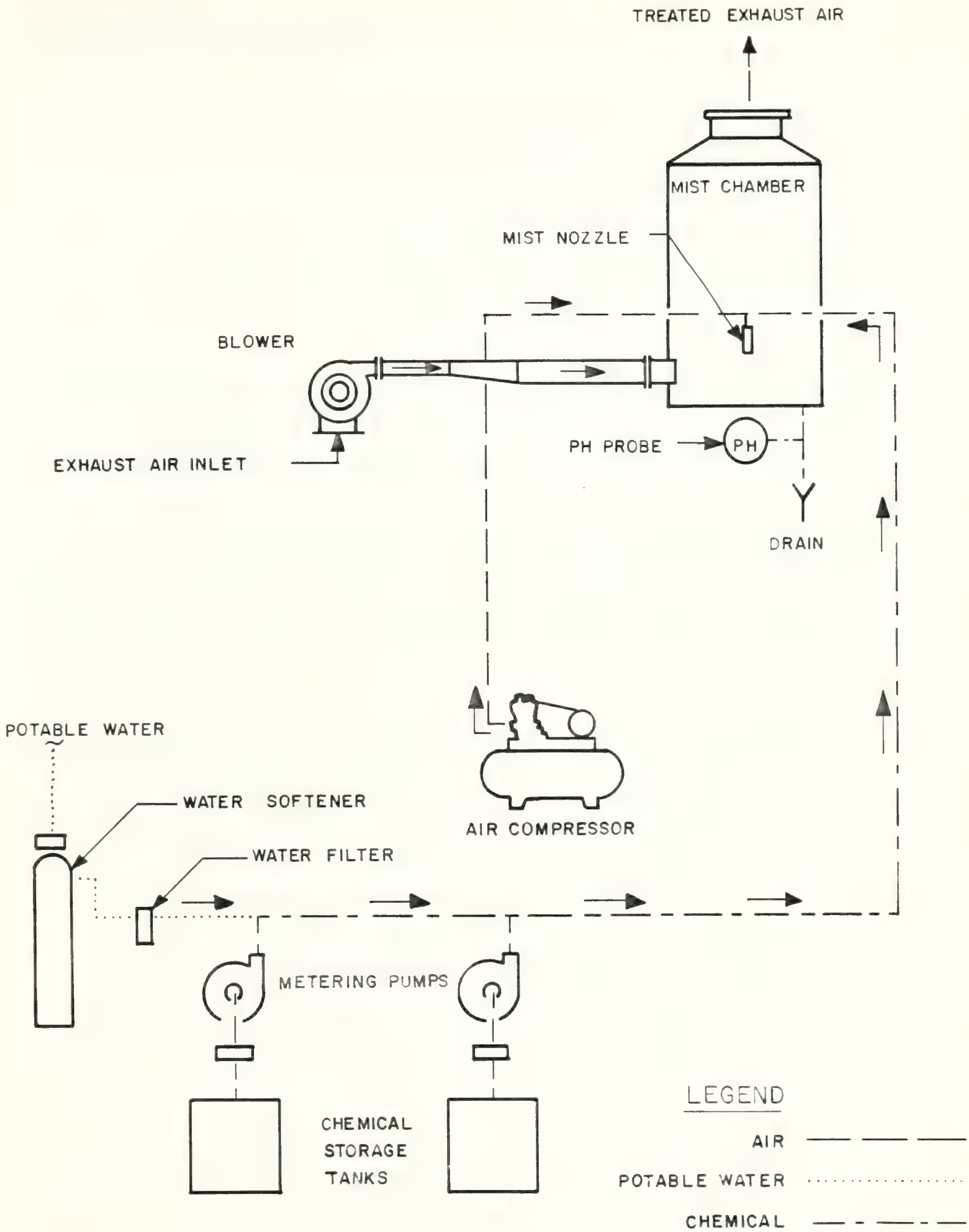

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FIGURE 6.2.2-1
SCHEMATIC DIAGRAM OF
MIST - CHAMBER SCRUBBER

To prevent blockage of the fine nozzles, softened potable water must be used to prepare the chemical solutions.

Mist chambers are widely used in industrial applications, where odors can be very severe. Mist chambers have also been installed at some municipal wastewater plants. Their installation has resulted in effective odor removal at many wastewater treatment plants.

Advantages of the mist chamber when compared to a packed-bed scrubber (which is described below) include: no packing or chemical recirculation; lower pressure drop through the chamber; and high surface area of the small mist droplets and long detention time in the chamber which increases the probability that odorous air molecules will come in contact with the scrubbing chemical.

Some of the disadvantages include complexity, larger space requirements and maintenance of air compressors, water softeners and chemical feed systems. Mist chambers are typically larger than packed towers because of the increased detention time used, and the mist nozzles require frequent cleaning to remove chemical deposits caused by the scrubbing solution and the oxidation reactions.

Because of the low solubility of VOCs in scrubbing liquid, scrubbing is not usually considered effective for removing VOCs. However, recent work done with mist chambers at composting operations shows high removals of VOCs. These surprising results might be attributed to surface effects allowing for removals much higher than calculated by Henry's law relationships.

Packed Tower

Packed tower scrubbers are filled with plastic media to create turbulence and increase interface area between the liquid and the air being treated. (See Figure 6.2.2-2.) In the tower, the odorous air and chemical solution are contacted in a fiberglass spray tower. A scrubbing liquid is recirculated from a sump at the base of the tower. Often, make-up chemicals are added to the sump to revive the potency of the recirculated scrubbing liquid.

There are numerous packed tower scrubbing systems at wastewater treatment plants. An advantage of the packed tower scrubbers is its smaller space requirements than that for mist chambers. The system is also somewhat easier to operate and maintain, and has a good performance record for removing odors (particularly from reduced sulfur compounds) from airstreams at wastewater treatment plants. It is important that all water and chemicals be removed from the scrubber exhaust if the scrubber is followed by a carbon system, since the larger droplets of the packed tower are more easily removed in a mist eliminator than much smaller droplets of a mist chamber.

Disadvantages when compared to a mist chamber include a higher pressure drop through the packing and a somewhat lower efficiency for odor control.

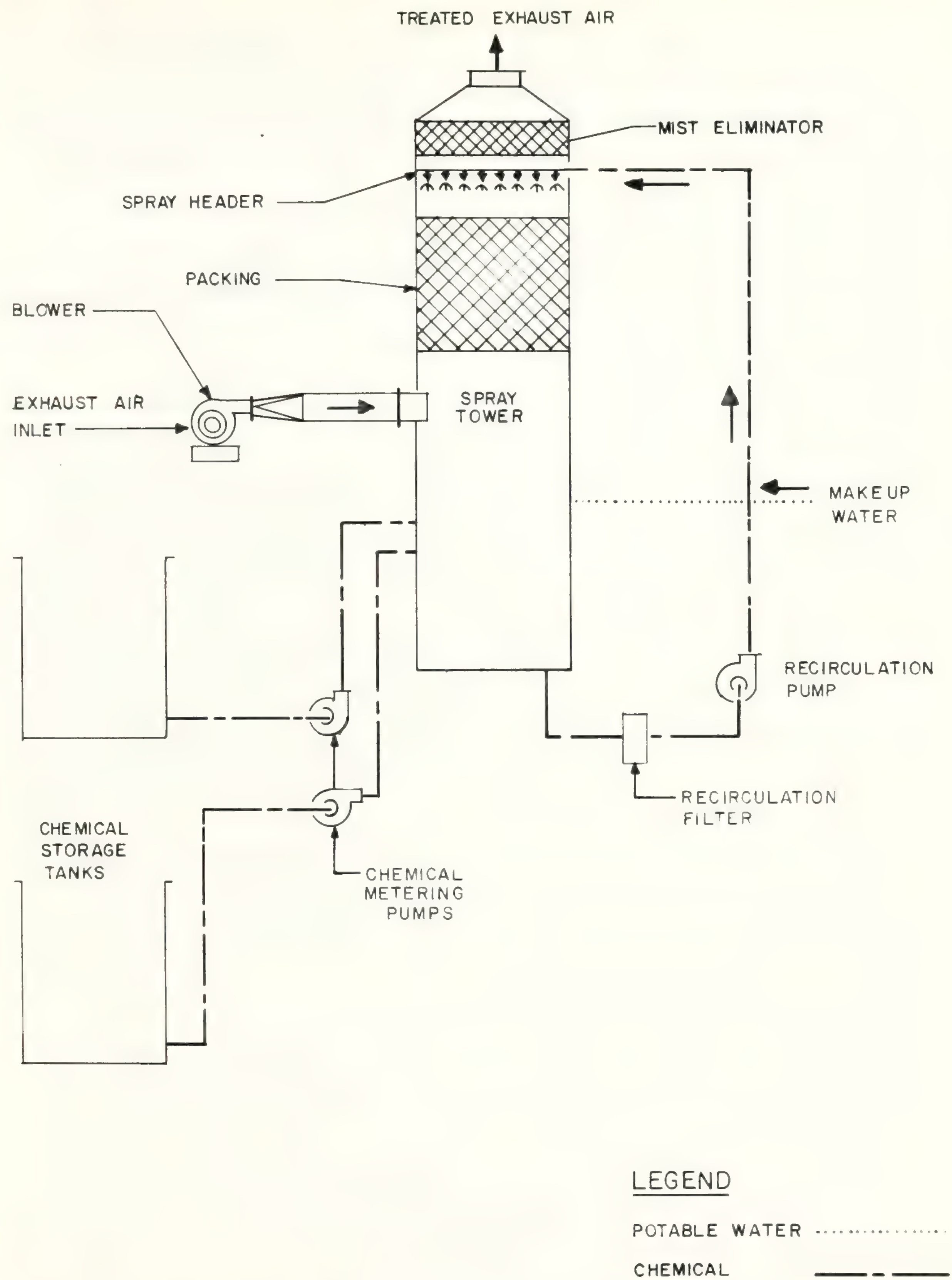

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FIGURE 6.2.2-2
SCHEMATIC DIAGRAM OF
PACKED - TOWER SCRUBBER

6.2.3 CARBON ADSORPTION

Granular activated-carbon systems have been through many years of refinement and technical development. They also have good operating records at wastewater treatment plants, and can be used for both odor and VOC control.

Carbon adsorption systems typically consist of beds of activated carbon ranging from about 24 to 48 inches in depth. (See Figure 6.2.2-3.) Air enters the vessel and flows through the bed where the VOCs and odor-causing compounds are adsorbed onto the carbon. After adsorption, the treated air is discharged through a stack to the atmosphere. Once the carbon bed is saturated, regeneration of the carbon is required by one of two methods: on-site regeneration with low pressure steam, or off-site regeneration involving total carbon replacement.

Adsorption of VOCs onto activated carbon is an accepted process for control of low concentrations of VOCs in air streams. Carbon adsorption systems (with unique configurations and operating procedures) are available from a number of manufacturers. Initially, carbon adsorption systems were used by industry to recover solvents from air streams containing high solvent concentrations. Recently, however, these systems have also been applied to remove low concentration VOCs from exhaust air streams. Several manufacturers of carbon adsorption systems have systems in operation which decrease VOC concentrations in an exhaust stream to below 5 ppm by volume.

For odor control, a proprietary activated carbon that is specifically designed for removal of hydrogen sulfide is available. The carbon is impregnated with sodium hydroxide, which chemically reacts with and neutralizes any hydrogen sulfide in the gas stream. The impregnated carbon can also remove large, nonpolar molecules such as organic hydrocarbons, by adsorbing or trapping these molecules within the carbon pores. Thus, odorous compounds can be removed by one of two mechanisms: chemical reaction or adsorption.

A new process involving the injection of ammonia into a gas stream entering an activated carbon bed is being investigated at the Owl's Head plant in New York City. The ammonia acts as a catalyst in a series of reactions, transforming hydrogen sulfide to elemental sulfur. The use of small volumes of ammonia increases the amount of sulfur that can be adsorbed before the bed is regenerated.

Advantages of carbon adsorption include ease of operation, reliability in controlling a wide range of odors, and the capability of removing VOCs in addition to odors. The disadvantages include high head loss through the adsorber, and carbon regeneration or replacement costs. Also, operating problems can occur in applications with high moisture contents.

Carbon can be thermally reactivated on- or off-site, or chemically regenerated onsite. To extend the life of a carbon bed, carbon scrubbers are typically used upstream of carbon adsorbers to remove the majority of odors, leaving the carbon as a polishing unit. The regeneration process produces a waste, either gaseous or liquid, that requires treatment or disposal.

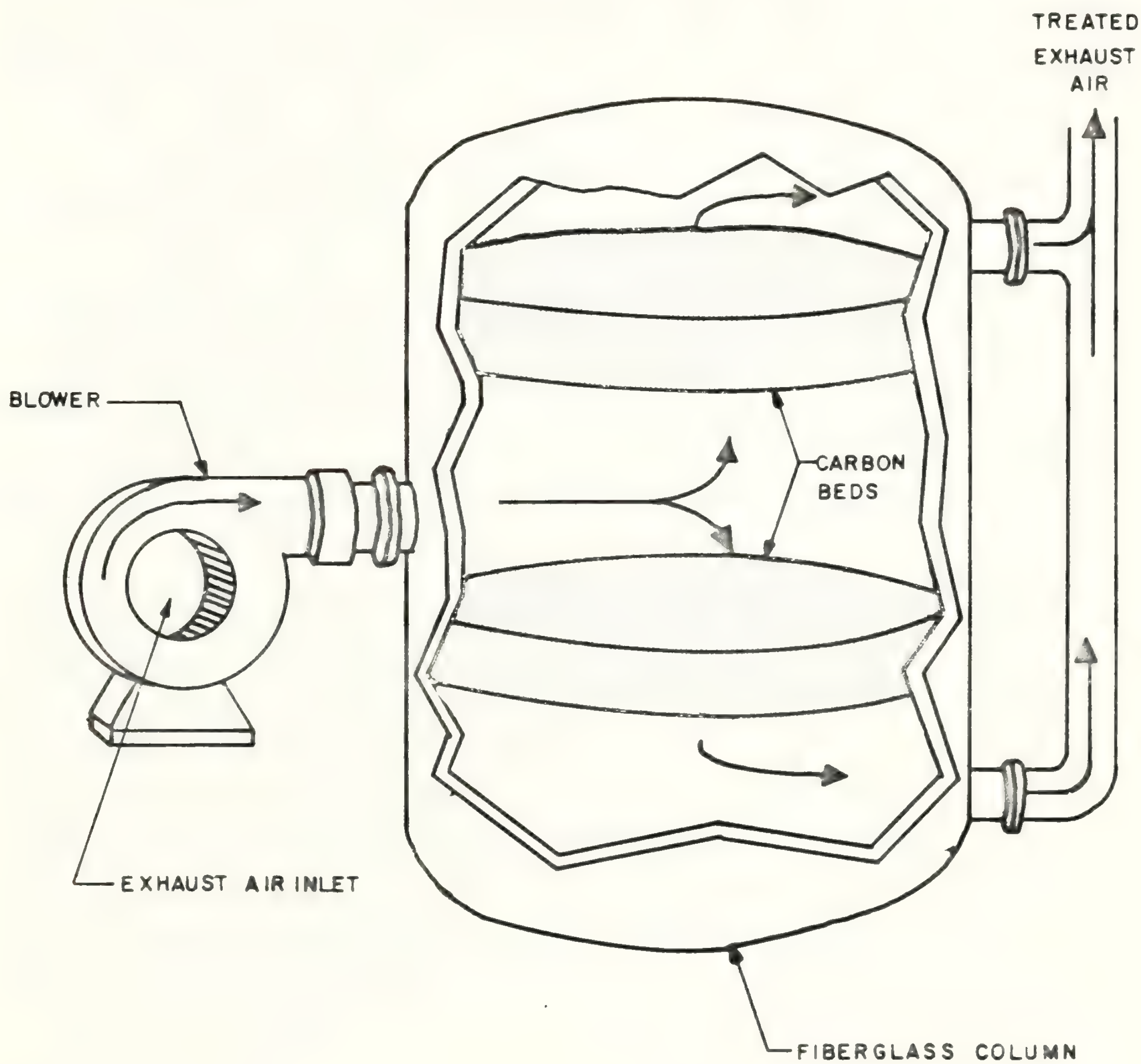

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FIGURE 6.2.2-3
SECTION OF DUAL - BED
ACTIVATED CARBON COLUMN

6.2.4 INCINERATION

Incineration is commonly used for VOC emission control and is quite capable of achieving a very high degree of VOC destruction. Various forms of incineration have been applied including flame, thermal, and catalytic incineration. Most incinerator manufacturers state that their systems are capable of reducing VOC emissions by 90 to 95 percent, even with low VOC concentrations in the inlet air stream.

Flame incineration is often used to remove VOC emissions when high concentrations support combustion. VOC concentrations in exhaust air streams from wastewater treatment processes are well below the lower combustion limit. Thus flame incineration is not practical.

Thermal incineration involves elevating the VOC-laden air temperature to 1400 to 1500 deg F and providing sufficient residence time to oxidize the organic contaminants. VOC-laden air is first passed through heat exchangers and preheated by the combustion gases exiting the unit. The process of preheating the air increases the thermal efficiency of the incineration by reducing fuel consumption. The air is then heated to 1400 deg F by auxiliary fuel in the combustion chamber, where the VOCs are oxidized. The hot exhaust gas passes through the heat exchangers and is discharged to the atmosphere. A secondary heat exchanger may be located downstream for additional heat recovery.

Catalytic incineration is sometimes used for VOC emission reduction. The catalyst increases the rate of oxidation by adsorbing the VOCs on its surface, thereby allowing the VOC-laden air to be oxidized at a lower temperature. Typical oxidation temperatures for catalytic incinerators range from 550 deg to 750 deg F. Catalysts can either be a precious metal coating on a ceramic structure or a fluidized bed of non-precious metal.

Catalytic incinerators cost more than thermal incinerators, but fuel consumption is significantly less. The primary disadvantage of catalytic incineration is the potential for poisoning of the catalyst. Chemicals known to poison catalysts include chlorine, fluorine, and phosphorus, as well as metals such as lead, zinc, and mercury. VOCs emitted from wastewater treatment processes vary considerably and the risk of catalyst poisoning is great. For this reason, catalytic incineration systems are usually not used for controlling VOC emissions from wastewater treatment processes.

6.2.5 CONDENSATION

Another technique for removal of gaseous VOC contaminants from an air stream utilizes the principle of condensation. In this method, the gas stream is cooled below the dew point of water and organic constituents, and the liquid is condensed and collected. It is necessary to have a vapor with a high dew point and high concentrations of contaminants for this method to be practical. In addition, this method is economically feasible only in situations where the recovery of the contaminant is profitable. Therefore, this method is not a practical alternative for control of the air streams at wastewater treatment plants.

6.2.6 SUMMARY OF CONTROL TECHNOLOGIES FOR AIR STREAMS

Several control systems are in common use for decreasing the concentration of odor-producing compounds and VOCs in gas streams. Of these, the most reliable system to control both odors and VOCs in air streams from wastewater treatment plants is wet scrubbing followed by activated carbon. Wet scrubbing would be used to remove odor-causing compounds, and the off-gas from the scrubbers would be directed to carbon adsorbers where residual hydrogen sulfide as well as VOCs would be removed. The overall removal efficiency for the system would be 95 to 99 percent for hydrogen sulfide and other reduced sulfur species, and around 85 percent for VOCs.

For cost purposes and for preliminary site layouts, single-stage wet scrubbing followed by carbon adsorption has been used. During final design, additional studies should be conducted to determine the most cost-effective method. These studies would investigate removal of individual VOCs at low concentrations.

The carbon system would consist of fixed-bed adsorption units that would require regular on-site desorption and periodic off-site carbon reactivation. Based on the low VOC concentration, carbon reactivation would be required approximately every year. The desorption cycle would be required every 2 to 4 days.

6.3 FACILITIES RECOMMENDED FOR CONTROLLING EMISSIONS

Facilities at Deer Island that will require odor and VOC control systems include the following:

- Winthrop Terminal Headworks
- Centrifugal Grit Chambers
- Grit Handling Building
- Primary Wastewater Treatment (splitter, influent channels and primary clarifiers)
- Screening Building Secondary Wastewater Treatment (splitter, selectors, aeration tanks, and influent channels for secondary clarifiers)

Preliminary sizing for these facilities was based on a ventilation rate of 12 air changes per hour for occupied spaces and three air changes per hour for unoccupied spaces. Occupied spaces include the Winthrop Terminal and the Grit Handling and Screening buildings. Unoccupied spaces include the primary clarifiers, influent channels, splitters, and secondary selector tanks.

Exhaust air volumes from the grit chambers and secondary aeration tanks were based on the actual air volume (pure oxygen for aeration tanks) introduced to the process.

In addition to normal ventilation, a maintenance ventilation volume was included for the primary clarifiers. The maintenance system allows for two clarifier basins to be out of service. During this time, these basins would be vented at 12 air changes per hour.

Table 6.3-1 lists the estimated exhaust air volumes for the Deer Island wastewater treatment facility and the Nut Island headworks. Because of the large distances between treatment facilities at Deer Island, six odor/VOC control facilities would be required. The table identifies the control facilities and lists the wastewater treatment facilities they will serve.

Each odor/VOC control facility would consist of wet scrubbers followed by carbon adsorption units. The exhaust air would be drawn through the units by fans and the treated air would be discharged through a stack to the atmosphere. Data on numbers of scrubbers, adsorbers and fans are shown on Table 6.3-1. Operating data are shown on Table 6.3-2.

Based on typical values from other wastewater treatment plants, the average hydrogen sulfide emission rate from all wastewater processes was estimated to be 15 ppmv. The selected control system, scrubbing followed by carbon adsorption, would remove 95 to 99 percent of the hydrogen sulfide from the air stream. We used 95 percent on emission calculations.

The majority of the VOCs would be removed by carbon adsorption. The activated carbon would be capable of removing 70 to 90 percent of the VOCs from the air stream. Eighty-five percent was used on emission calculations.

Depending on the VOC adsorbed, activated carbon is capable of removing 0.05 lb to 0.25 lb of VOC per pound of carbon. For this study, the activated carbon capacity was based on 0.15 lb VOC per pound of carbon. After being in use from about three days to a week, the activated carbon will become saturated with VOC. At that time, a standby column will be put into operation and hot nitrogen gas or steam will be passed through the saturated column to desorb the VOCs. Desorption will take about eight hours. The desorbed VOCs will be burned in a fume incinerator located at each air emission control facility. The incinerators will be designed to achieve 99.99 percent destruction of VOCs, and emissions will be about 0.1 tons/yr.

Once a year, the carbon will be removed, transported to an off-site facility for direct thermal regeneration, then returned for use. About 40 truck loads will be required for hauling. In order to lessen truck traffic on Deer Island, the carbon from only one or two activated-carbon units at a time (out of 24) could be removed for regeneration.

Several questions remain to be resolved about the proposed activated carbon adsorption system. One of these is the life of the activated carbon between regenerations. The capacity of the activated carbon is related to the concentration of the VOC in the gas stream. Because the concentration of VOCs in the gas stream is low, the interval between regenerations might be decreased. Another question is the removal rate of individual VOCs at low concentrations within a mixture of numerous VOCs. These questions need further study and examination in a pilot program.

6.4 DEMONSTRATION OF BEST AVAILABLE CONTROL TECHNOLOGY (BACT)

The justification of BACT is influenced by the selection of wastewater-treatment processes for

Table 6.3-1

DESCRIPTION OF AIR EMISSION CONTROL FACILITIES

Location	System Capacity	No./Size of Packed Tower Scrubbers	No./Size of Dual Bed Carbon Adsorbers	No./Size of Exhaust Fans	Building Size
Winthrop Terminal	15,300 scfm	(2) 6 ft diameter	(2) 12 ft diameter	(2) 15,300 scfm	50 ft x 80 ft x 28 ft height
East Air Emission Control Complex:	--	--	--	--	85 ft x 150 ft x 30 ft height
Grit Chambers	19,000 scfm	(2) 6 ft diameter	(2) 12 ft diameter	(2) 19,000 scfm	--
Grit Handling Bld.	21,000 scfm	(2) 7 ft diameter	(2) 12 ft diameter	(2) 21,000 scfm	--
Primary Clarifiers	39,800 scfm	(2) 9 ft diameter	(2) 12 ft diameter	(2) 39,800 scfm	--
Clarifier Maint.	22,100 scfm	(1) 7 ft diameter	(1) 12 ft diameter	(1) 22,100 scfm	
West Air Emission Control Complex:	--	--	--	--	80 ft x 125 ft x 30 ft height
Grit Chambers	19,000 scfm	(2) 6 ft diameter	(2) 12 ft diameter	(2) 19,000 scfm	--
Primary Clarifiers	32,600 scfm	(2) 8 ft diameter	(2) 12 ft diameter	(2) 32,600 scfm	--
Clarifier Maint.	22,100 scfm	(1) 7 ft diameter	(1) 12 ft diameter	(1) 22,100 scfm	--
Screening Building	21,000 scfm	(2) 7 ft diameter	(2) 12 ft diameter	(2) 21,000 scfm	60 ft x 75 ft x 28 ft height
Secondary Treatment (East)	21,000 scfm	(2) 7 ft diameter	(2) 12 ft diameter	(2) 21,000 scfm	50 ft x 80 ft x 28 ft height
Secondary Treatment (West)	18,000 scfm	(2) 5 ft diameter	(2) 12 ft diameter	(2) 18,000 scfm	50 ft x 80 ft x 28 ft height
Nut Island Headworks	55,000 scfm	(3) 7 ft diameter	(4) 12 ft diameter	(4) 27,500 scfm	65 ft x 100 ft x 20 ft height

Table 6.3-2
Power and Chemical Requirements for Air Emission Control Facilities

Location	Power (kw)	Sodium hydroxide (gpd)	Sodium hypochloride (gpd)
Winthrop Terminal	200	56	38
East Air Emission	240	84	57
West Air Emission	200	54	37
Screening Building	80	22	15
Secondary Treatment (East)	120	18	12
Secondary Treatment (West)	120	15	10
Nut Island Headworks	200	56	38

which a control system is proposed. In the case of Deer Island, air pollution control systems are proposed for the entire facility, up to and including the aeration tanks. For air emissions, the secondary clarifiers and the disinfection tanks will remain uncovered and uncontrolled.

To evaluate a selected control system with respect to its ability to meet BACT, it is necessary to evaluate its energy, economic, and environmental impacts. Impacts on energy consumption are deemed adverse when the selected system requires an exorbitant amount of energy or a source of energy not readily available within the area. Economic impacts are deemed adverse when the annualized cost of control exceeds a certain predefined amount. Environmental impacts are deemed adverse when the ambient impacts of the released pollutants exceed critical environmental levels established for the project under review -- in this case the AALs presented in Section 3. In general, the economic and environmental aspects of an evaluation will dictate the justification of a proposed system as BACT.

Table 6.4-1 presents a summary of the emission calculations presented previously in Section 5 for the flow and load conditions representing the annual operating regime for the oxygen feed system. This table shows an uncontrolled emission rate for the PPL/HSL equal to 98.24 tons/yr, and a controlled rate equal to 14.66 tons/yr. The total VOC emission estimates are based on the range of the total VOC-to-individual constituents relationship defined earlier as 20 to 50.

As shown in Table 6.4-1, the proposed control system -- covering and control of air emissions up to the secondary clarifier -- will reduce the total VOC emissions from the treatment plant by an amount ranging between 1700 and 4200 tons/yr. Preliminary cost estimates indicate the annual cost of control is approximately $800,000 for the primary treatment units and $1,825,000 for the secondary treatment units. These estimates do not include the cost of the basin covers because covers are required in an oxygen/activated sludge system. The amount of VOCs controlled in each unit ranges from 1050 to 2640 tons/yr in the primary system, and 620 to 1540 tons/yr in the secondary system. These values equal to a cost effectiveness of $300-760/ton of VOC removed in the primary system and $1180-2960/ton of VOC removed in the secondary system.

The uncontrolled sources remaining are the secondary clarifiers and the disinfection tank. Two potential options for control exist: additional stripping and control of volatile constituents in the aeration tank; and installation of a capture and control system.

The first option will yield little reduction in the annual controlled VOC emission rate. Table 6.4-2 shows that the controlled emissions of PPL/HSL VOCs would change only about 5 percent (15.33 tons per year vs. 14.66 tons per year) if air were used to aerate the activated sludge system. It was judged, however, that the oxygen-activated sludge system would be more reliable for wastewater treatment. Because of the small difference in emissions between the oxygen and air systems, the more-reliable system (oxygen activated sludge) should be retained.

The second option would involve collection and control of the VOCs released from the uncontrolled treatment units. The emission rate from the disinfection area is so small that collection and treatment of the emission can yield only insignificant reductions. Thus control

Table 6.4-1
Summary of Annual Emissions for the Oxygen Feed System Before and After Control, tons/yr.

Unit	Uncontrolled Emissions			Controlled Emissions		
	Individual VOCs	TRS	Total VOC	Individual VOCs	TRS	Total VOC
Grit/Primary Clarifiers	61.25	6.85	1225-3062	8.51	0.35	170-426
Aeration Tanks	35.68	5.15	714-1786	4.84	0.26	97-242
Secondary Clarifiers	1.20	0.27	24 - 60	1.20	0.27	24- 60
Disinfection	0.11	0.02	2 - 6	0.11	0.02	2- 6
Total	98.24	12.29	1965-4914	14.66	0.90	293-734

TABLE 6.4-2

COMPARISON OF AIR EMISSIONS WITH AIR ACTIVATED SLUDGE AND OXYGEN ACTIVATED SLUDGE

	EMISSIONS OF PPL/HSL VOCs IN TONS PER YEAR Based on average flows and loads, weighted by high and low groundwater			
	Air activated sludge		Oxygen activated sludge	
	Uncontrolled	Controlled	Uncontrolled	Controlled
Grit chamber weir	18.65	2.59	18.65	2.59
Primary Splitter Box	28.34	3.94	28.34	3.94
Clarifier weir	14.26	1.98	14.26	1.98
Secondary splitter box	23.04	3.20	23.04	3.20
Aeration basin	16.08	2.09	3.98	0.58
Aeration basin weir	5.11	0.62	8.69	1.06
Secondary clarifier surface	0.42	0.42	0.54	0.54
Secondary clarifier weir	0.40	0.40	0.66	0.66
Chlorine contact	0.09	0.09	0.11	0.11
SUM	106.39	15.33	98.27	14.66

Note: Sum of PPL/HSL VOCs to Deer Island = 307 tons per year

of this source is not considered technically or economically feasible. The emissions from the secondary clarifier are essentially distributed equally between the clarifier surfaces and the effluent weirs. Even without preparing a cost estimate for the pollution control devices, the cost to capture the emission far exceeds any reasonable economic range. For example, the cost of basin covers averages approximately $35/square foot. The surface area of the secondary clarifiers is approximately 600,000 square feet. Table 6.4-1 showed that the secondary clarifiers will emit between 24 and 60 tons VOC/yr. Complete capture and 85 percent control of this emission will yield a net reduction ranging between 21 and 52 tons VOC/yr. The cost to provide the enclosure would be roughly $21 million. In determining the annualized cost, a capital recovery factor of 0.121 is used (based on a 15 yr recovery period and an 8.625 percent interest rate). This recovery factor yields an annualized capital cost for the enclosure equal to $2.5 million, and a cost effectiveness factor ranging from $48,000 to over $100,000/ton VOC removed. These costs, even before considering the cost of the equipment, are tremendously excessive.

6.4.1 SUMMARY OF BACT SYSTEM

In summary, the selected control system consists of a wet scrubber for odor control followed by an activated carbon adsorber for VOC control. Implementation of this control strategy will produce a reduction in the VOC emissions from the proposed treatment system of 1672 to 4180 tons/yr as compared to an uncontrolled scenario. Further capture and control of the VOCs released from the secondary clarifiers and the disinfection tanks does not meet the economic constraints of BACT. Furthermore, this level of capture and control is not practiced anywhere. Finally, the PSD review requirements for TRS (total reduced sulfur) are not triggered, because controlled emission rate for the reduced sulfur species is much less than the 10 tons/yr significant emission level. Upon satisfying the environmental constraints of BACT, the selected air pollution control system will be in full compliance with the provisions of BACT required by the DEQE. The environmental impact assessment of the proposed configuration is presented in Section 7.

7.0 AIR QUALITY MODELING AND AMBIENT IMPACT ASSESSMENT

7.1 INTRODUCTION

This Section presents the methodology used to conduct an ambient air quality impact assessment of the potential emissions from the proposed wastewater treatment facilities. It concludes with a discussion of the results obtained from the assessment.

An ambient air quality impact assessment is a necessary part of the preconstruction approval process for any proposed source. The potential impacts that are assessed vary from project to project and can include a comparison of expected ambient air quality impacts of a project with the National Ambient Air Quality Standards (NAAQS), a Prevention of Significant Deterioration (PSD) increment, an Allowable Ambient Level (AAL), or an odor threshold for one or many pollutants proposed for release to the atmosphere.

The procedure for ambient air quality impact assessment is based on guidance available from Federal and State air pollution control agencies. The available guidance specifies appropriate methods for estimating a source's potential ambient impact and defines the data required to ensure consistent assessment from source to source and region to region. In the case of preconstruction review, an ambient air quality impact assessment is performed using computer programs that simulate movement of air pollutants between the release point and downwind ambient air based on specific source characteristics and detailed meteorological data.

Computer programs used for conducting ambient air quality impact assessments are commonly referred to as "air dispersion models." Many different dispersion models are available and approved for use by EPA. Models for a wide variety of situations and emission characteristics allow ambient impact assessments for both particles and gases: in flat terrain, elevated terrain, or some combination of terrain features (terrain is considered elevated when the surrounding land surfaces are above the top of the proposed release point or stack); for short-term averaging times (i.e., 1-h, 3-h, 8-h, or 24-h); and for long-term averaging times (i.e., 30-day, 3-month, annual, or 5-year annual composite).

7.1.1 OBJECTIVES OF THE CURRENT ASSESSMENT

The first objective of the impact assessment was to calculate the expected worst-case air-quality impact of emissions from facilities proposed at Deer Island and Nut Island. The calculated impacts were compared with the most critical allowable ambient impact measure applicable to the project. The ultimate objective was to demonstrate that the worst-case ambient air quality impacts for all pollutants expected to be released from the proposed facilities would be less than the allowable levels. In this analysis, three sources of emissions were not included: (1) exhaust from fume incinerators used to burn the VOCs thermally desorbed from activated carbon (see Section 6.3); (2) emissions from the air purging system from the oxygen activated sludge facilities; and (3) Nut Island Headworks.

Exhaust from the fume incinerators was not modeled because their mass loadings will be only a

fraction of the organics put into the system. Moreover, their high exhaust temperature will provide a higher plume rise than other sources of VOCs, and the impact of the exhaust will be at locations different from the impact of the other VOCs.

The air purging system will be used infrequently (less than once a year), and no treatment is planned for this small source of VOCs. Emissions from Nut Island will be less than current emissions, and controls similar to those proposed for Deer Island will be proposed for Nut Island.

For the three sources, air quality modeling might be needed for an air quality permit.

7.2 DERIVATION OF ALLOWABLE IMPACT LEVELS

Section 3 presented a list of the VOCs measured in wastewater in the MWRA sewers and the AAL or odor threshold limit for each.

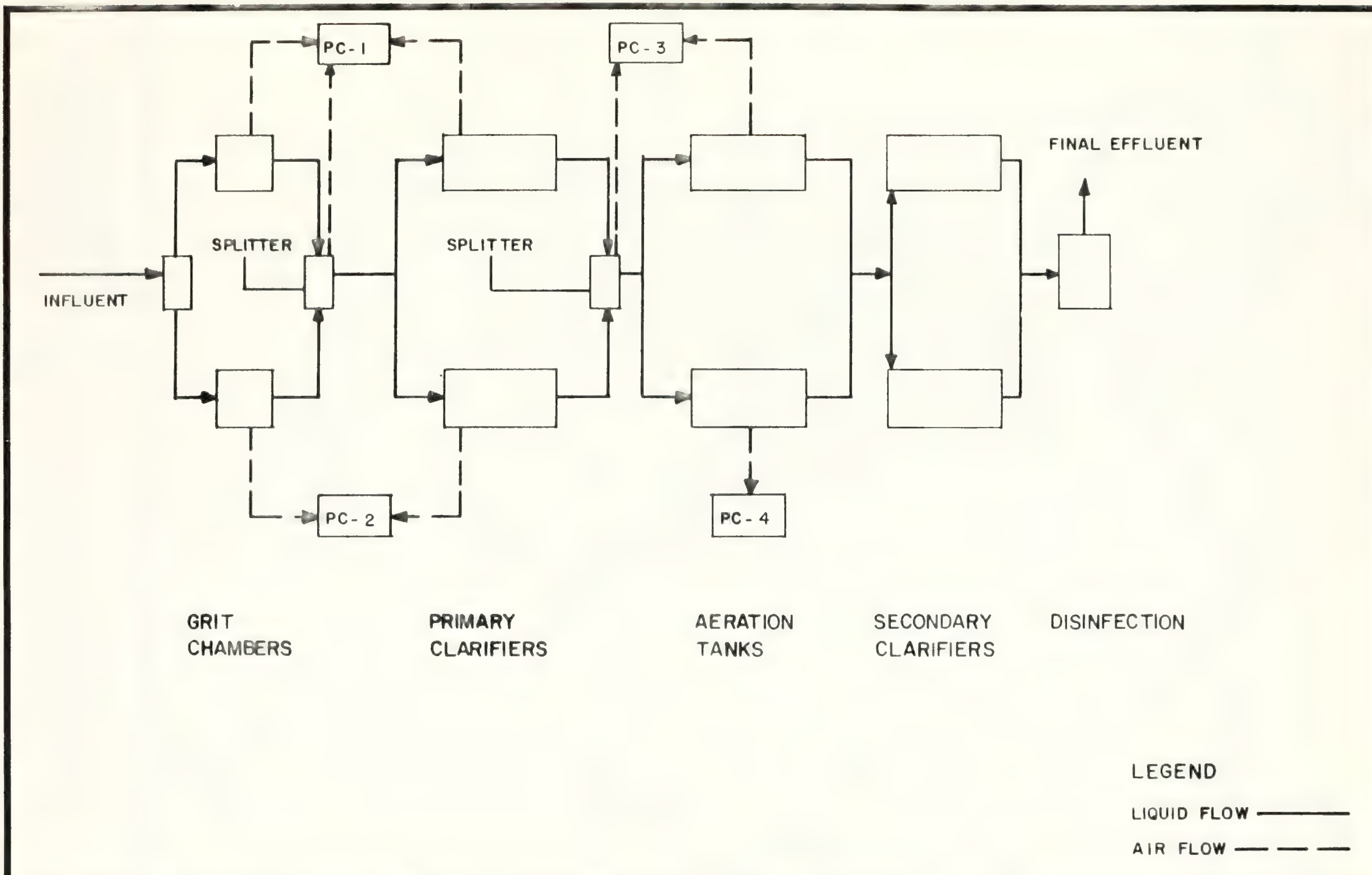
7.3 SOURCE CONFIGURATIONS

All of the wastewater units on Deer Island up to and including the effluent weirs of the aeration tanks will be covered. The air pollutant emissions from these units will be treated in a wet scrubber/activated carbon control system prior to being released to the atmosphere through one of several stacks on the Island. Emissions from the remaining sources, i.e., the secondary clarifiers and the disinfection basins, will be released to the atmosphere without control over a large area represented by the surfaces of the treatment units. Figure 7.3-1 presents a block flow diagram which describes the relationship between the emission source and air pollution control equipment on Deer Island.

To accurately model the pollutant dispersion, the parameters of each release must be defined in terms of location, strength, height, temperature, momentum, and bouyancy. These aspects are discussed below.

7.3.1 SOURCE LOCATIONS

Figure 7.3.1-1 presents a diagram of Deer Island showing the placement of the various wastewater treatment units and the locations of the air pollution control equipment referenced in Section 6 and diagrammed in Figure 7.3-1. The locations of sources were established using the Universal Transverse Mercator (UTM) coordinate system. Coordinates were established for the point sources at the point of release; for areas sources, the southwest corner coordinates were obtained after 45° rotation into a north-south orientation, as required by the dispersion model.



MASSACHUSETTS WATER RESOURCES AUTHORITY

FIGURE 7.3-1
CONTROL EQUIPMENT ORIENTATION USED FOR AIR QUALITY MODELING

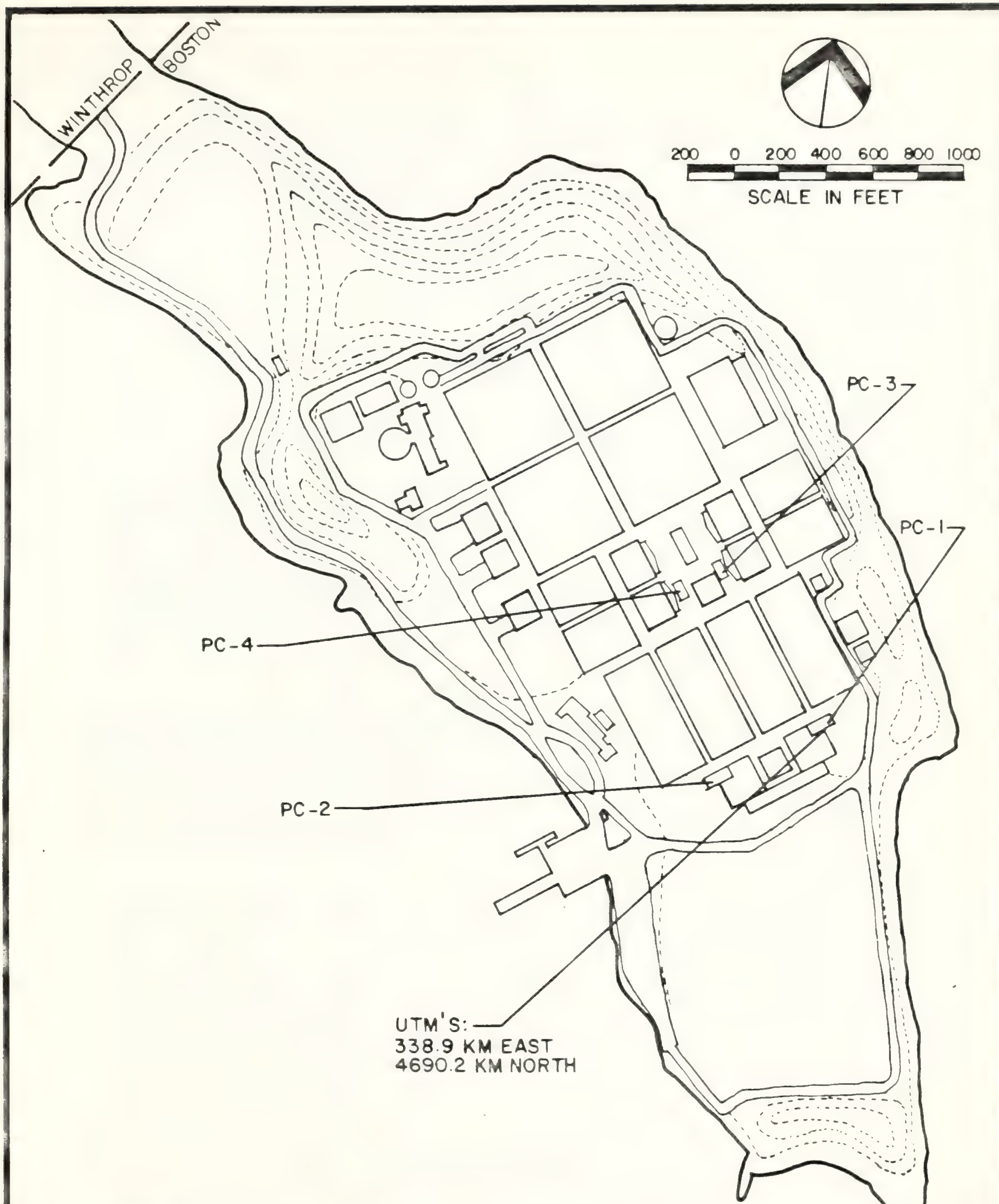


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FIGURE 7.3.1-1
DEER ISLAND EMISSION CONTROL FACILITIES LOCATIONS

7.3.2 EMISSION RATES

Emission rates for each pollutant were calculated using the procedures presented in Section 5 and the control efficiencies presented in Section 6. As indicated in Figure 7.3-1, the treatment plant will be divided into two halves, and the wastewater treatment units within each half will be vented to different air pollution control systems. Because the construction will entail completion of one half before beginning the second half, the first half of the plant will contain a few more sources than the second half. The calculation results presented in Section 5 provided the emission rate for each pollutant by treatment unit. The emission points are described as an allocation of the total emission by treatment unit to individual emission points is presented in Table 7.3.2-1.

7.3.3 EMISSION SOURCE PARAMETERS

For modeling, the Deer Island emission sources were described using six point source releases and five area-source releases. The area sources consisted of four sources describing the secondary clarifiers and one source describing the disinfection area. The point sources modeled include two points more than are actually present on the Island. These two additional points were used to represent the emission point for the primary splitter box and the aeration splitter box, and were assigned parameters identical to those of the actual stack. Thus, the model actually sees two point sources at the exact same location for PC-1 and PC-3. The model was set up in this manner to allow calculation of unit concentrations from two different sources using the same stack. Additional discussion of this item is presented in Section 7.4.1.

Stack parameters were established for the primary treatment control system stacks and the secondary treatment control system stacks at Deer Island. The stack heights were established as the Good Engineering Practice (GEP) stack height required to avoid plume downwash. The buildings in the areas of the stacks will meet the definition of "squat-type" in that the length and width will be greater than the height; thus GEP was defined as 2.5 times the height of the nearest building. In all cases, the nearest building was 30 ft (9.1 m) high.

The stacks were assumed to be identical within each treatment area even though one of the stacks in each area will handle a greater air flow. This assumption was made for practical reasons in that the plant is likely to be built symetrically. The design stack diameter is based on an exit velocity of about 60 ft/s (18.3 m/s) at the condition of maximum flow. The actual velocity input to the model was then calculated based on the actual flow exiting the stack under normal operating conditions. All temperatures were assumed to be at ambient conditions of 68 deg F (20 deg C). Table 7.3.3-1 presents a summary of the stack parameters assigned to each controlled release point.

7.4 SCREENING ANALYSIS

The first step in the dispersion modeling analysis was to set up a screening model, i.e., an analysis designed to identify the constituents that had the potential to produce a high impact.

Table 7.3.2-1

Fractions of Emissions Allocated to Emission Points

Treatment Unit	Emission Point PC-1	PC-2	PC-3	PC-4	AR-5	AR-6	AR-7	AR-8	AR-9
Grit Chambers	0.5	0.5							
Primary Splitter	1.0								
Primary Weir	0.5	0.5							
Aeration Splitter			1.0						
Aeration Tank			0.5	0.5					
Aeration Weir			0.5	0.5					
Secondar Clarifier					0.25	0.25	0.25	0.25	
Secondary Weir					0.25	0.25	0.25	0.25	
Disinfection Basin									1.0

Table 7-.3.3-1
Stack Parameters for the Air Pollution Control Device Stacks

Stack	Height, m (ft)	Diameter, m (ft)	Flue Gas Exit Velocity, m/s (ft/s)	Temperature K (^{o} F)
PC-1	22.7 (75)	1.8 (6.0)	14.3 (47)	293 (68)
PC-2	22.7 (75)	1.8 (6.0)	9.3 (30)	293 (68)
PC-3	22.7 (75)	0.73 (2.4)	18.4 (60)	293 (68)
PC-4	22.7 (75)	0.73 (2.4)	15.2 (50)	293 (68)

A secondary purpose of the screening modeling was to provide a methodology to establish critical receptor locations. This level of assessment is consistent with the EPA Guideline on Air Quality Models (U.S.EPA, EPA-450/2-78-002R) for determining receptor grids. To assure a proper degree of conservativeness in the calculated concentrations using the screening model, several constraining assumptions were made:

- worst-case concentrations were estimated regardless of location

- conversion factors were used to convert worst-case 1-hour concentrations to 24-hour averages

- all meteorological conditions were considered, even when such conditions leading to the worst case estimates may not persist over a 24 hour period

- multiple source impacts were calculated as the sum of the maximum individual source impacts regardless of source location, source-receptor distances, or sensitivity to variable meteorological conditions.

7.4.1 RATIONALE AND SCREENING MODEL SELECTION

Two types of sources are proposed for Deer Island. These include the four point sources (stacks) and the area sources representing the secondary clarifiers and disinfection basins. Because no approved procedures exist for screening level analyses of area sources, area sources were not treated in the screening level analysis. Constituents that were expected to be released from an area source were not subjected to screening-level analysis.

The EPA-approved PTPLU Model provides a simple screening tool for determining short-term maximum impacts of point source emissions. This model is a simplified point source Gaussian model that includes variable stack and release characteristics, variable meteorological conditions over a range of wind speeds and atmospheric stability categories, optional gradual plume rise, stack-tip downwash, and buoyancy-induced dispersion. The model calculates concentrations for each set of meteorological conditions and specifies the distance to the receptor where the maximum concentration occurs.

The rationale for the use of the PTPLU Model stems from its ability to quickly model many stack configurations using a large number of meteorological conditions. This allows consideration of dispersion of individual sources under a variety of different conditions and estimation of the 1- hour concentrations associated with each condition. The 1-hour concentration estimates were subsequently adjusted to a 24-hour averaging period for comparison with the allowable ambient impact levels.

7.4.2 SCREENING MODEL INPUTS AND RESULTS

Application of the PTPLU Model was consistent with general modeling practice, i.e., each point source was input to the model with its given stack parameters and the appropriate control

options selected. Because of limitations in the treatment of area sources, only pollutants estimated to be released entirely from a point source were considered in the screening analysis. The results of the PTPLU analysis were reviewed to determine the maximum concentrations over a 24-hour period. To be conservative, the maximum one-hour concentration was selected regardless of meteorological conditions.

Four separate emissions sources were modeled corresponding to the four stacks that will be located on the Deer Island site. The rural option of the model was selected to be consistent with land use surrounding Deer Island, as recommended by the guideline on air quality models using the Auer technique.

Other options were chosen to be consistent with modeling requirements and guidelines as well as to match the detailed modeling assessment described in Section 7.5. Meteorological inputs used default values of the PTPLU Model, which provides a range of wind speeds that were deemed applicable to each atmospheric stabilty class. For example, wind speeds ranging from 0.5 to 20.0 m/s at ground level were applied (before adjustment via extrapolation to stack height). Receptors were assumed to be located at ground level. Source parameters were those presented in Table 7.3.3-1. A unit emission rate of 1.0 g/s was used throughout the screening analysis to allow the concentration estimates to be normalized and applied to all pollutants of concern.

As stated earlier, pollutants were not screened if a portion of the emissions were from one of the uncontrolled area sources. Constituents released from both point and area sources were evaluated only in the detailed modeling assessment as described in Section 7.5. Based on the results presented in Section 5, virtually one hundred percent of the potential emissions of the following pollutants are from point sources:

- benzene
- ethylbenzene
- methylene chloride
- tetrachloroethene
- toluene
- trans-dichloroethene (1,2)
- trichloroethene
- trichlorofluoromethane
- acetone
- 2-butanone
- total xylenes
- napthalene
- chlorobenzene
- benzyl alcohol

The maximum 1-h concentrations derived from the PTPLU analysis are presented for each of the four stacks in Table 7.4.2-1. For each point source, two concentration estimates are presented. The first concentration represents the maximum 1-h value derived from the PTPLU output. The second concentration represents the 24-h adjusted concentrations. For this analysis an adjustment factor of 0.4 as recommended by EPA was used to convert from a 1-h to a

Table 7.4.2-1
Unit Results of PTPLU Screening Analysis of Point Sources

Source	NormalizedMaximum 1-h Concentration, $\mu g/m^3$	NormalizedMaximum 24-h Concentration, ug/m^3	Distance to Maximum, m
PC-1	20.28	8.11	256
PC-2	31.39	12.56	265
PC-3	39.19	15.68	287
PC-4	47.78	19.11	263

24-h concentration. (EPA-450/4-77- 001, October 1977).

Review of the results in Table 7.4.2-1 indicates that the maximum impacts will typically occur within about 300 m of the individual sources. Because the shorelines are within this distance, the maximum impacts might occur there. Further review of the PTPLU results for other wind speed/stability class combinations indicates that maximum concentrations could be expected to occur at downwind distances of 500 m or less for all meteorological conditions. These results formed the basis for selection of appropriate downwind distances in the detailed analysis described in Section 7.5.

Using the results presented in Table 7.4.2-1 along with the pollutant specific emissions for a maximum load/minimum flow scenario resulted in the 24-hour pollutant-specific concentration estimates stated in Table 7.4.2-2.

The concentrations of the individual four point sources were added together, disregarding the location of the maximum impact or the meteorological conditions under which they occurred. This methodology was thought to provide a factor of safety and to assure that any chemical constituents screened would not have an adverse ambient air impact. Of the 14 chemicals under consideration in the screening analysis, 12 could have been dropped from further detailed consideration. The maximum 24-hour concentrations of the 12 chemicals were less than 50 percent of the applicable ambient impact level. All chemical constituents, however, were included in the detailed analysis.

7.5 DETAILED MODELING ANALYSIS

The detailed dispersion modeling methodology used in the analysis of emissions of various chemical constituents from the proposed Deer Island secondary treatment facility was selected on the basis of the required source and modeling criteria which included:

- large area sources emitting at ground level in addition to point sources
- multiple gaseous emissions
- a 24-hour averaging period that should be based on the average of hourly concentrations
- ability to specify discrete receptor locations
- site-specific meteorological data

The modeling analysis herein fulfills these requirements and meets the requirements of the Guideline on Air Quality Models (EPA-450/2-78-027R, July 1986). The following subsections present the model selection, input/output requirements and selection, the meteorological data selected, the receptor grid used, the derivation of chemical-specific concentration estimates for 24-h averages due to each source, and the summary of the resultant impacts analysis and comparison to the 24-h limiting concentrations.

Table 7-4.2-2

Maximum 24-h Pollutant-Specific Screening Results, μg/m³

	Maximum 24-h Concentration					
Constituent	PC-1	PC-2	PC-3	PC-4	Total	AAL
Benzene	0.04	0.02	0.04	0.00	0.10	4.0
Ethylbenzene	0.12	0.06	0.18	0.06	0.42	120
Methylene chloride	0.62	0.32	0.55	0.00	1.49	8.0
Tetrachloro-ethene	0.32	0.12	0.22	0.00	0.66	20.6
Toluene	0.31	0.16	0.33	0.06	0.86	51.0
Trans-dichloro-ethene (1,2)	0.10	0.05	0.09	0.00	0.25	110
Trichloro-ethene	0.17	0.08	0.30	0.18	0.72	20.4
Trichloro-flouro-methane	0.11	0.06	0.09	0.00	0.26	762
Acetone	0.04	0.02	0.05	0.00	0.11	8000
Butanone	0.01	0.00	0.01	0.00	0.02	160
Xylenes	0.49	0.26	0.44	0.00	1.18	59.0
Napthalene	0.23	0.12	0.21	0.00	0.56	14.0
Chlorobenzene	0.10	0.05	0.09	0.00	0.24	6.3
Benzyl alcohol	0.01	0.00	0.01	0.00	0.02	NA

7.5.1 DETAILED MODEL SELECTION

The dispersion model selected for detailed analysis of the 24-h ambient impacts was the short-term version of the Industrial Source Complex (ISCST) Model (EPA-450/4-86-005a, June 1986). The ISCST Model is recognized by the Guideline on Air Quality Models as a suitable model for complex sources and for fugitive emissions. In this analysis, the UNAMAP 6 version (the most recent version and currently available through NTIS or the National Computer Center in Research Triangle Park) was used for all estimates.

To accomodate the emission calculation procedure described in Section 5, the ISCST model was linked with the emission calculation programs in a separate program referred to as "AMBIENT". AMBIENT is basically a postprocessor adapted from EPA's emission/dispersion model that allows the user to input unit emission rates to ISCST for subsequent prorating for actual rates.

The AMBIENT model was used to apply the calculated emissions from the facility to the ISCST receptor grid. Each treatment unit was assigned to an ISC source group that contained the stack data and emission rates for the applicable stack. AMBIENT also allows the user to input a pollutant-specific control efficency factor for each source. The ISCST run was made with source group emission rates as described later. Using actual meteorological data, expected impacts of the source groups were calculated for each receptor in μg/m3.

7.5.2 CHARACTERIZATION OF SOURCES AND EMISSIONS

For the purposes of detailed dispersion modeling, the sources presented in Section 7.3 were characterized and input to the ISCST Model. Six point and five area sources were used to characterize the Deer Island facility. This allowed a more simplified treatment of the point source analysis than modeling each component individually. It also allowed more consistent format for proration of the unit emission impacts to pollutant specific estimates. The identification of the individual sources in the ISCST analysis and the cross-reference to the Deer Island facility identification are as follows:

- o Grit-chamber weir - ISCST source Nos. 1-2
- o Primary splitter weir - ISCST source No. 3
- o Primary-clarifier weir - ISCST source Nos. 1-2
- o Aeration splitter - ISCST source No. 4
- o Aeration basin - ISCST source Nos. 5-6
- o Aeration basin weir - ISCST Nos 5-6
- o Secondary-clarifier surface - ISCST source Nos. 7-10
- o Secondary-clarifier weir- ISCST source Nos. 7-10
- o Disinfection - ISCST source No. 11

Several groupings of the ISCST sources were implemented to facilitate the calculation of pollutant specific concentrations in the model. The ISCST model allows the consideration of various source combinations so that the individual as well as user-selected combinations of sources may be determined. The source groupings used in the Deer Island study were:

- o Source group 1: ISCST Nos. 1-2 (PC-1,2)
- o Source group 2: ISCST No. 3 (PC-1)
- o Source group 3: ISCST No. 4 (PC-3)
- o Source group 4: ISCST Nos. 5-6 (PC-3,4)
- o Source group 5: ISCST Nos. 7-10 (AR-5,8)
- o Source group 6: ISCST No. 11 (AR-9)

These source groups allowed the proration of the normalized concentrations to those consistent with the appropriate source- emission combinations.

Because of the multitude of pollutants requiring an impact assessment, the goal was to establish a methodology that would allow calculation of unit reponse concentrations, i.e., the impact of 1 g/s from a point source or 1 $g/s/m^2$ from an area source. To facilitate this goal without tremendously increasing the computations required in the emission calculation phase, emissions were calculated by unit (as described in Section 5) and the ISCST model emissions inputs were specified based on the fraction of each unit's emission that was delivered to each individual stack on Deer Island (as presented previously in Table 7.3.2-1). For example, ISCST sources 1 and 2 were each input with an emission rate of 0.5 g/s, because one-half of the pollutants released from the primary treatment systems go to each of these two stacks. Source 3, however, with identical parameters as source 1, was input with an emission rate of 1 g/s because all of the pollutants released from the primary splitter go to only one stack. This allowed easy proration when considering the pollutant-specific emissions in the ambient program.

7.5.3 METEOROLOGICAL DATA

Calculation of maximum 24-h concentrations in ISCST was based on the use of five years of meteorological data. These data were obtained in hourly format from the National Weather Service office at Logan Airport (Station No. 14739) for the surface parameters, and from Portland, Maine (Station No. 14764) for the mixing height data. These data were processed together into the appropriate format for the ISCST Model. The ISCST model directly accessed these files during processing.

7.5.4 MODEL OPTIONS

The use of the ISCST Model required that multiple input/output options be selected before the model would perform the desired calculations in the desired format. In all cases, the options were selected in concurrence with those recommended by the Guideline on Air Quality Models and with those consistent with the requirements of the analysis. Table 7.5.4-1 presents all major options used in this analysis.

Table 7.5.4-1
Options Used in the ISCST Analysis of the Proposed Deer Island Secondary Treatment Facility

Option Description
Meteorological data were input using preprocessed data and Option = 1
The rural mode was used for the Deer Island site.
Wind profile exponents for P-G stablility classes A-F were the following:
rural applications--0.07, 0.07, 0.10, 0.15, 0.35, 0.55.
Vertical potential temperature gradients used were ISCST default values.
Buoyancy-induced dispersion was used.
Wind system measurement height was set to 10 meters.
Rectangular UTM coordinates were used for all receptor locations.
Building aerodynamic downwash calculations were not required.
Program control parameters, receptors, and source input data were output.
24-hour concentrations were calculated and output for each source group.
The calms processor was used in all modeling.

7.5.5 RECEPTORS

The screening analysis performed in Section 7.4 indicated that the facility stacks have their maximum impacts at less than 300 m, and that the maximum impacts may occur at or near the shoreline. To accomodate this possibility, receptors were placed along the shoreline as well as within another 100 m or so along the shoreline in potentially critical receptor locations as determined from screening analysis. Further review of the PTPLU results for less critical wind speed/stability class combinations indicated downwind distances of 500 m or less for maximum impact for all meteorological conditions. Maximum concentrations for ground-level area source emissions occur typically near the sources. This fact, along with the screening analysis discussed in Section 7.4 for the point sources, was sufficient justification for the placement of receptors for this detailed modeling.

Figure 7.5.5-1 presents the general layout of the selected receptor locations. The general wind persistence patterns are shown in Figure 7.5.5-2, which is a windrose for 1985 for Logan Airport. These patterns were also used as a guide to receptor placement. Given these selection tools as well as the resource and time constraints due to the number of sources requiring processing over all hours of a year, the number of receptors was limited to 68. Of these 68 receptors, five were located in surrounding communities as shown in Figure 7.5.5-3. A larger, more complex grid of receptors was not deemed necessary because the selected locations provided representative coverage of the maximum concentration locations and any estimates made at these sites were conservative.

7.5.6 ISCST UNIT EMISSION RESULTS

Table 7.5.6-1 presents the maximum concentration calculated for each source group included in the ISCST analysis using a unit emission rate for each of five years of meteorological data. The maximum concentrations resulted from using 1985 meteorological data for all source groups except the PC-3 and 4 source group, which had a maximum resulting from the use of 1984 data. Because the primary treatment area, which is in ISCST source groups PC-1 and PC-2, has a greater emission rate than the secondary treatment area, the 1985 meteorological data were selected to represent the year with the greatest potential for a worst-case ambient impact. This data set was then used for the detailed analysis discussed in Section 7.6

Table 7.5.6-2 presents additional detail on the 1985 24-hour concentration results. This table presents the maximum calculated 24-hour concentration for each source group and identifies the location of the receptor where the maximum had occurred. The critical days of analysis are also presented. These results as they are presented provide little insight into the pollutant-specific concentrations because no correction has been made for actual emissions on a source-by-source or pollutant-by-pollutant basis.

The results presented in Table 7.5.6-2 were used to provide detail on locations and the spatial distribution of the maximum impacts produced by the various source groups modeled. These locations are also given in Figure 7.5.6-1, which shows the critical receptors were typically

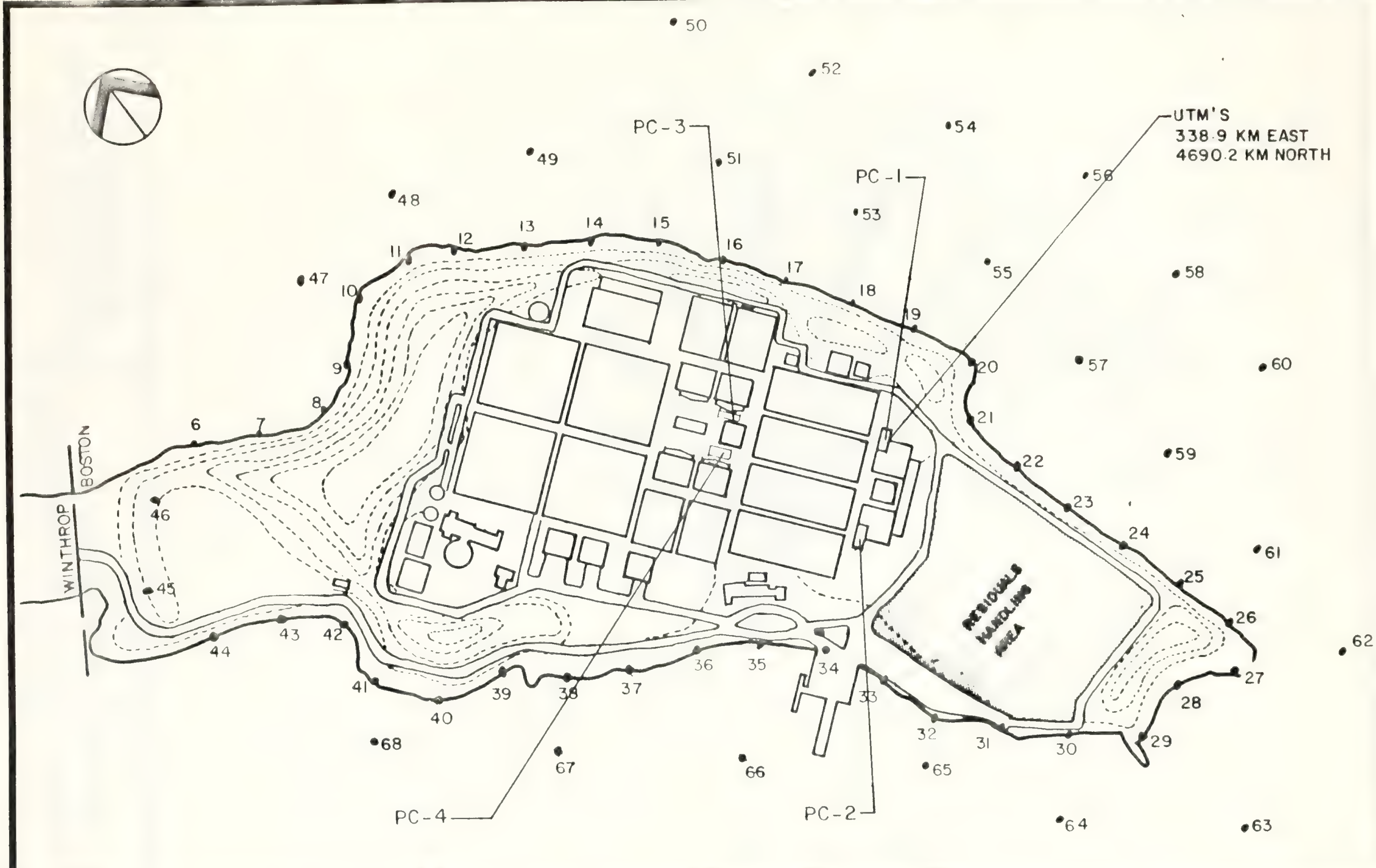

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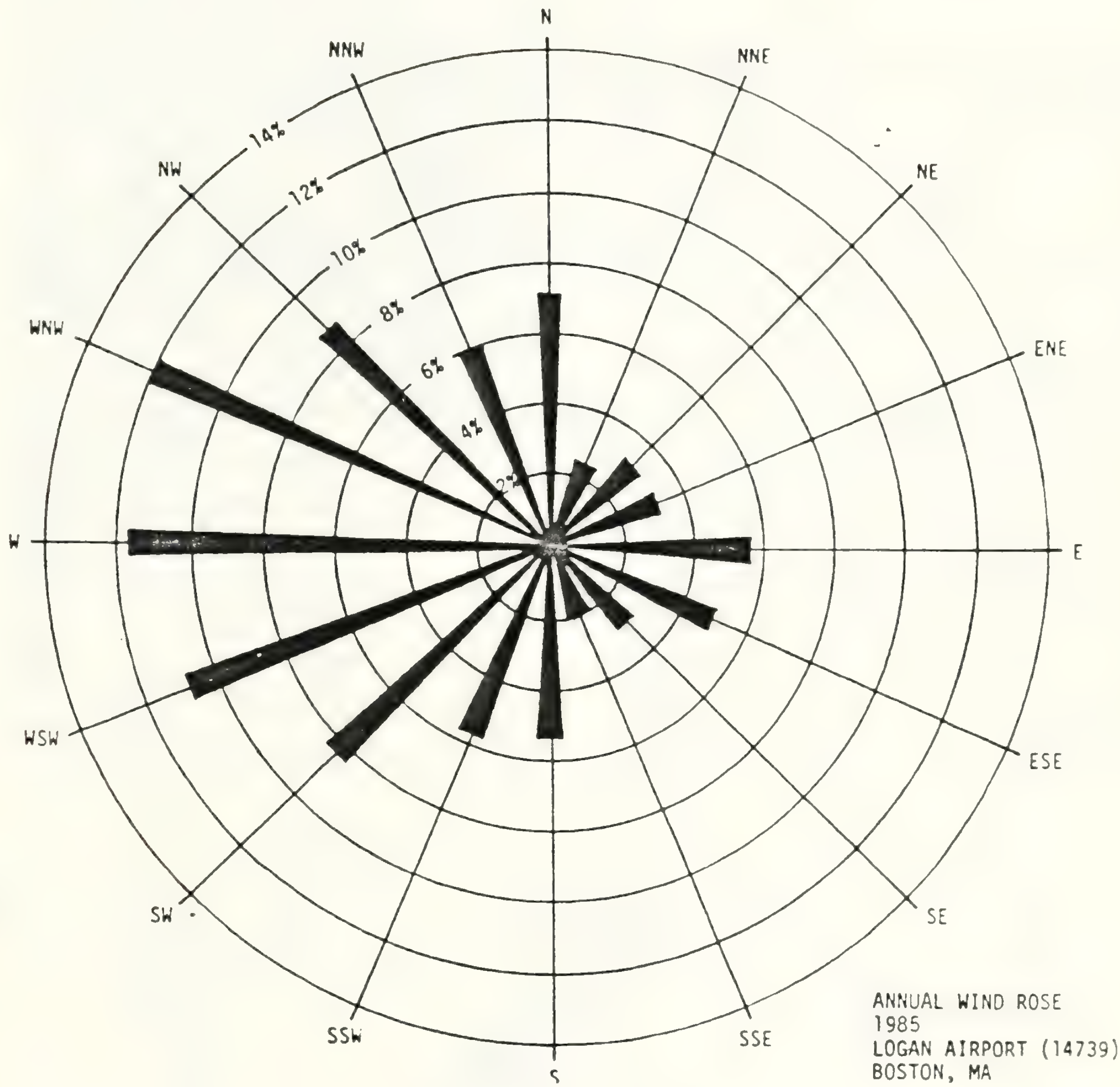
FIGURE 7.5.5-1
EMISSION CONTROL FACILITIES
AND RECEPTORS



MASSACHUSETTS WATER RESOURCES AUTHORITY	FIGURE 7.5.5-2 ANNUAL WIND ROSE FOR LOGAN INTERNATIONAL AIRPORT, 1985

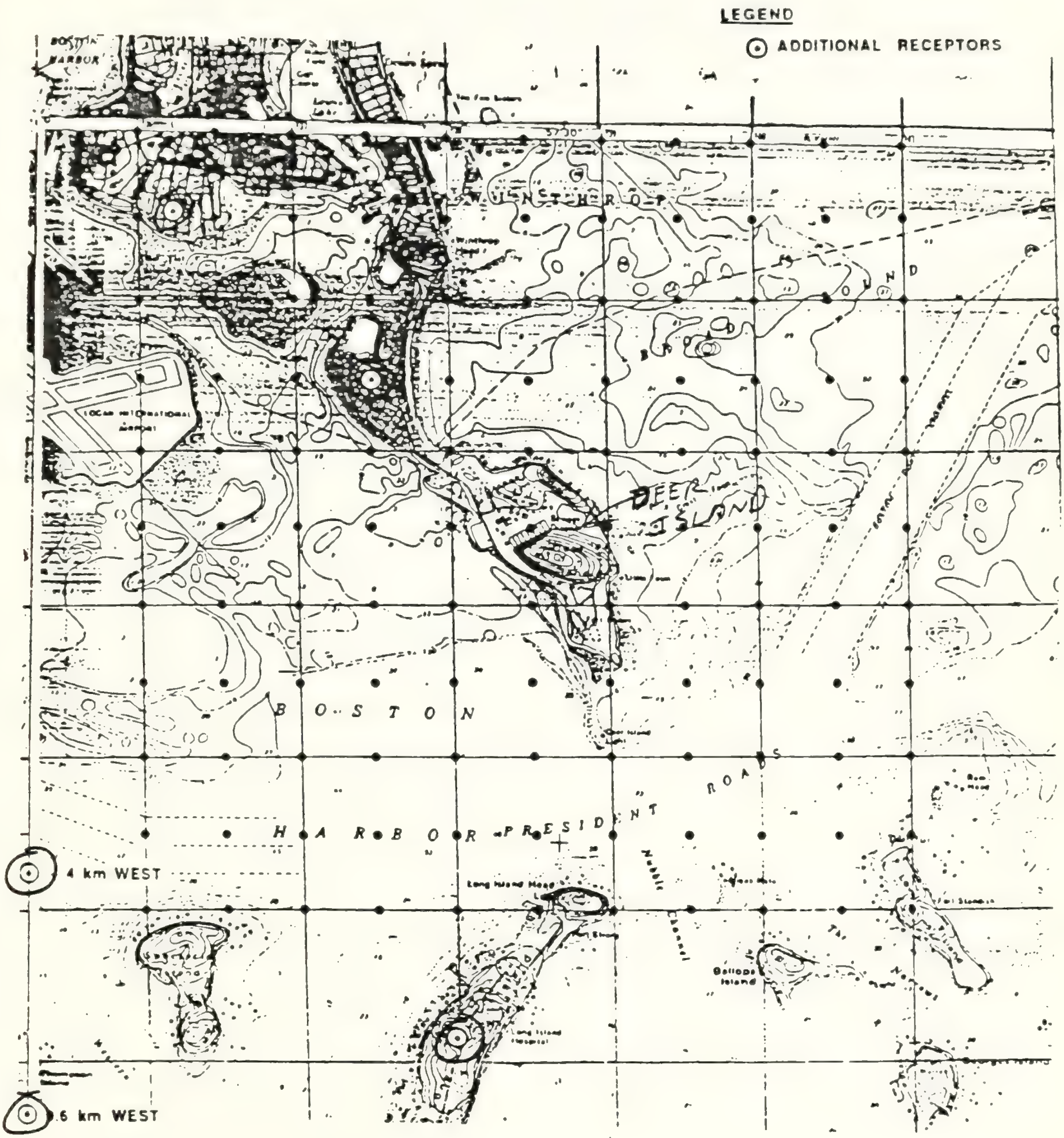


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FIGURE 7.5.5-3
ADDITIONAL RECEPTORS USED IN THE DEER ISLAND ISCST DISPERSION MODELING

Table 7.5.6-1
Maximum 24-hour normalized Concentrations For Each Year of Meteorological Data, $\mu g/m^3$

Source Group No.	Meteorological Year 1981	1982	1983	1984	1985
PC-1, 2	5.6	5.7	5.5	7.9	9.3
PC-1	6.2	6.3	5.7	6.1	8.6
PC-3	10.3	9.4	9.2	11.8	12.2
PC-3, 4	8.9	8.9	7.8	11.8	10.2
AR-5 to 8	977,978	1,237,975	1,273,632	999,077	1,227,326
AR-9	1,912,789	2,613,030	3,583,894	2,780,472	3,738,323

Table 7.5.6-2
Unit Emission Results of ISCST Analysis using 1985 Data.

Source Group No. (ISCNO)	Description	Maximum Normalized 24-h Concentration, $\mu g/m^3$	Critical Day	Coordinates, m	
				X	Y
1 (1,2)	PC-1, PC-2	9.3	130	339,300	4,690,500
2 (3)	PC-1	8.6	130	339,300	4,690,500
3 (4)	PC-3	12.2	37	338,800	4,689,690
4 (5,6)	PC-3, PC-4	10.2	223	339,200	4,690,700
5 (7-10)	clarifiers	1,227,326	295	338,780	4,690,730
6 (11)	disinfection	3,738,323	295	338,850	4,690,660

located at or near the shoreline of Deer Island. Because of the spatial distribution of sources over the property, the maximum impacts from individual sources were not expected to occur at colocated receptors. This is in fact the case as can be seen in the figure. The maximum concentrations due to the secondary clarifiers (AR-5 to 8) occurred at a nearby shoreline receptor (No. 14) to the northeast of the facility, as did that of the disinfection basin (AR-9) just southeast of the secondary clarifier impact point (No. 15). The maximum combined impact of the primary treatment system (PC-1 and 2) occurred about 300 m east of stack PC-1 (No. 54). The maximum concentrations due to the combined impacts of PC-3 and PC-4 occurred at a receptor northeast of the facility (No. 52), within about 300 m of the shoreline. Because the majority of the emissions from the proposed facility originate from the point sources (PC-1 to PC- 4), the maximum combined impact of all Deer Island sources was expected to occur within 200 m or so around the eastern shoreline of Deer Island.

As a check on the critical receptor locations and days found in the ISCST Model analysis, a grid of receptors at 100 m intervals was placed around each critical receptor (see Figure 7.5.6-2). For each critical day noted in Table 7.5.6-2, a separate ISCST Model analysis was performed to ascertain if the previously determined critical receptor was in fact located at the point of maximum expected impact. The detailed grid in Figure 7.5.6-2 provided a sufficient selection of receptor locations to render such a finding. The results of this critical day analysis showed that the critical receptor locations in the original ISCST Model analysis grid (Figure 7.5.5-2) were higher than any additional receptors in the detailed grid for the critical day analysis. Thus, the original selection of receptor locations was sufficent for finding the locations of maximum impacts.

7.6 RESULTS OF DETAILED ANALYSES

The AMBIENT program was used to postprocess all ISCST Model results (1-hour concentrations for each source at each receptor for each hour of meteorological data) obtained using the 1985 meteorological data. The 1985 meteorological data were used for this analysis because they had been demonstrated to yield the highest ambient concentrations for the most important sources.

Table 7.6-1 presents a summary of the AMBIENT results on a 24-h basis along with a comparison to AALs or other critical impact level. These maximum ambient impacts are based on the emission rate produced from the minimum-flow, maximum-load scenario and represent the worst-case potential impacts from the facility on a short-term basis. The maximum unit emission concentrations from the ISCST Model analysis were used disregarding the fact that the temporal concurrence of worst-case emissions and dispersion meteorology may have a very low frequency of occurrence.

The comparison of maximum calculated ambient impacts to critical ambient levels indicates that the ambient impact of constituents present in the Deer Island influent and released from the treatment system will be much less than the critical levels for all except trichloroctuene even at the shoreline of Deer Island.

Figure 7.5.6-1 presents the locations of the maximum ambient impacts as determined by the

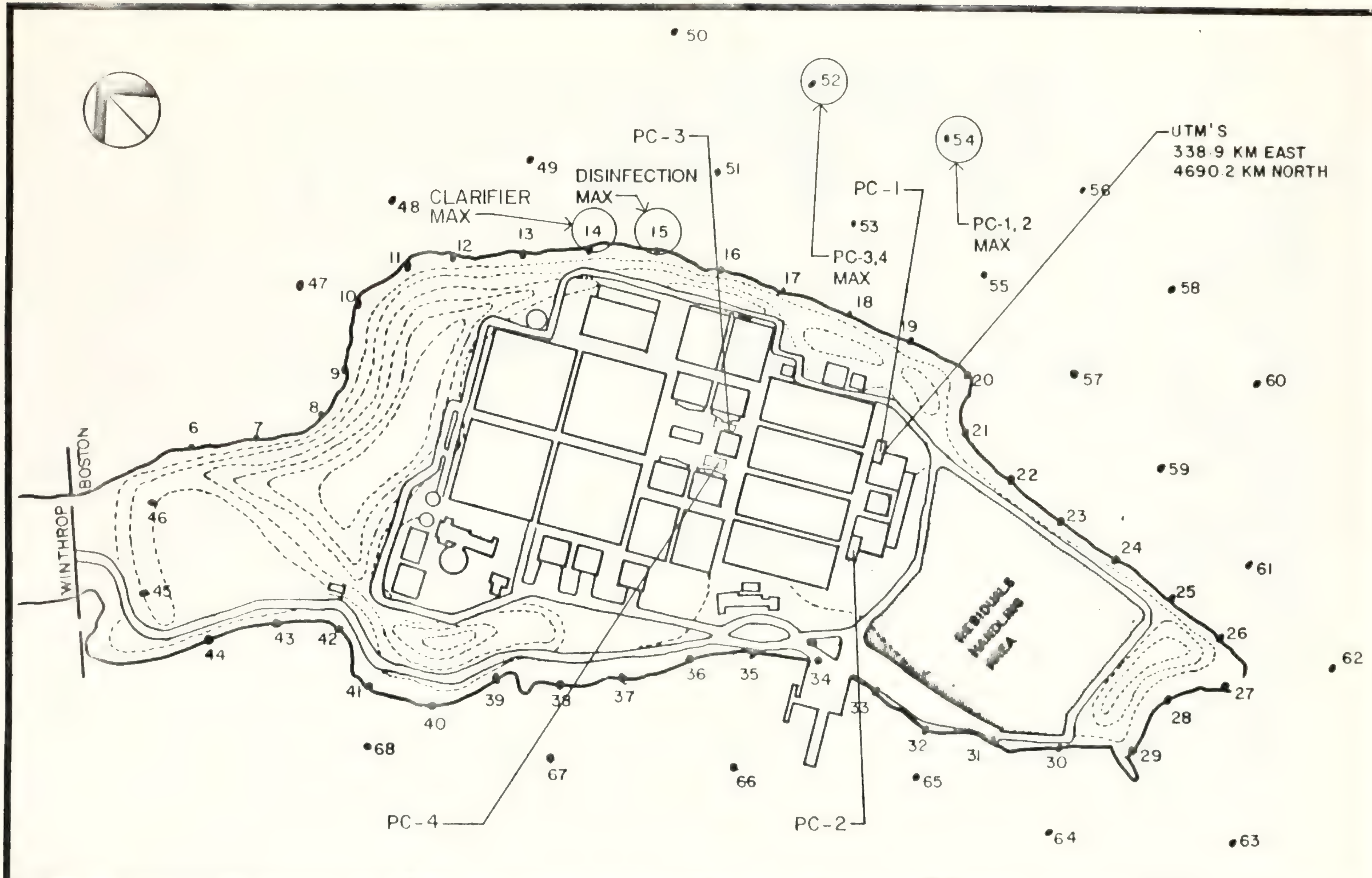

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FIGURE 7.5.6-1
LOCATIONS OF IMPACTS FOR
DEER ISLAND EMISSION SOURCES

Table 7.6-1
Comparison of Critical and Calculated 24-hour Concentrations for Constituents Released From the Proposed Deer Island Treatment Facility, $\mu g/m^3$

Constituent	Odor Threshold	Allowable Ambient Level	Worst-case 24-hour Concentration
Acetone	240000	8000	0.08
Benzene	15000	1.2	0.07
Benzyl alcohol	24700	NA[1]	0.01
Bromomethane	NA	2.6	0.53
2-Butanone (MEK)	29900	160	0.02
2-Butanone, 3-methoxy, 3-methyl	NA	NA	0.10
Carbon disulfide	663	200	0.24
Chlorobenzene	980	6.3	0.18
Chloroform	10^6	1.44	0.24
o-Cresol	1170	100	<0.01
p-Creso	2.02	12.0	<0.01
1,2-Dichlorobenzene	24400	82.0	0.73
Dimethyl disulfide	5.0	NA	<0.01
Dimethyl sulfide	2.57	NA	0.01
Ethyl benzene	615000	120	0.22
Ethyl ether	2550	160	0.33
Hexone (MIBK)	1950	280	0.40
Methyl mercaptan	4.19	NA	0.16
Methylene chloride	88000	2.4	1.1
Naphthalene	NA	14.0	0.41
N-Nitrosodiphenylamine	NA	NA	<0.01
Pentane, 2-meth, 2,4,4-trimethyl	NA	NA	0.17
Phenol	195	52.0	<0.01
2-Propanone, 1-flouro	NA	NA	0.03
Styrene	639	39.0	0.30
1,1,2,2-Tetrachloroethane	3480	1.2	0.49
Tetrachloroethene	34400	0.18	0.43
Toluene	649	51.0	0.55
Trans-1,2-dichloroethylene	341	108	0.18
1,1,1-Trichloroethane	553000	1300	0.52
Trichloroethene	272000	20.4	0.33
Trichlorofluoromethane	NA	762	0.20
Xylene	220	59.0	0.88

[1] No data available.

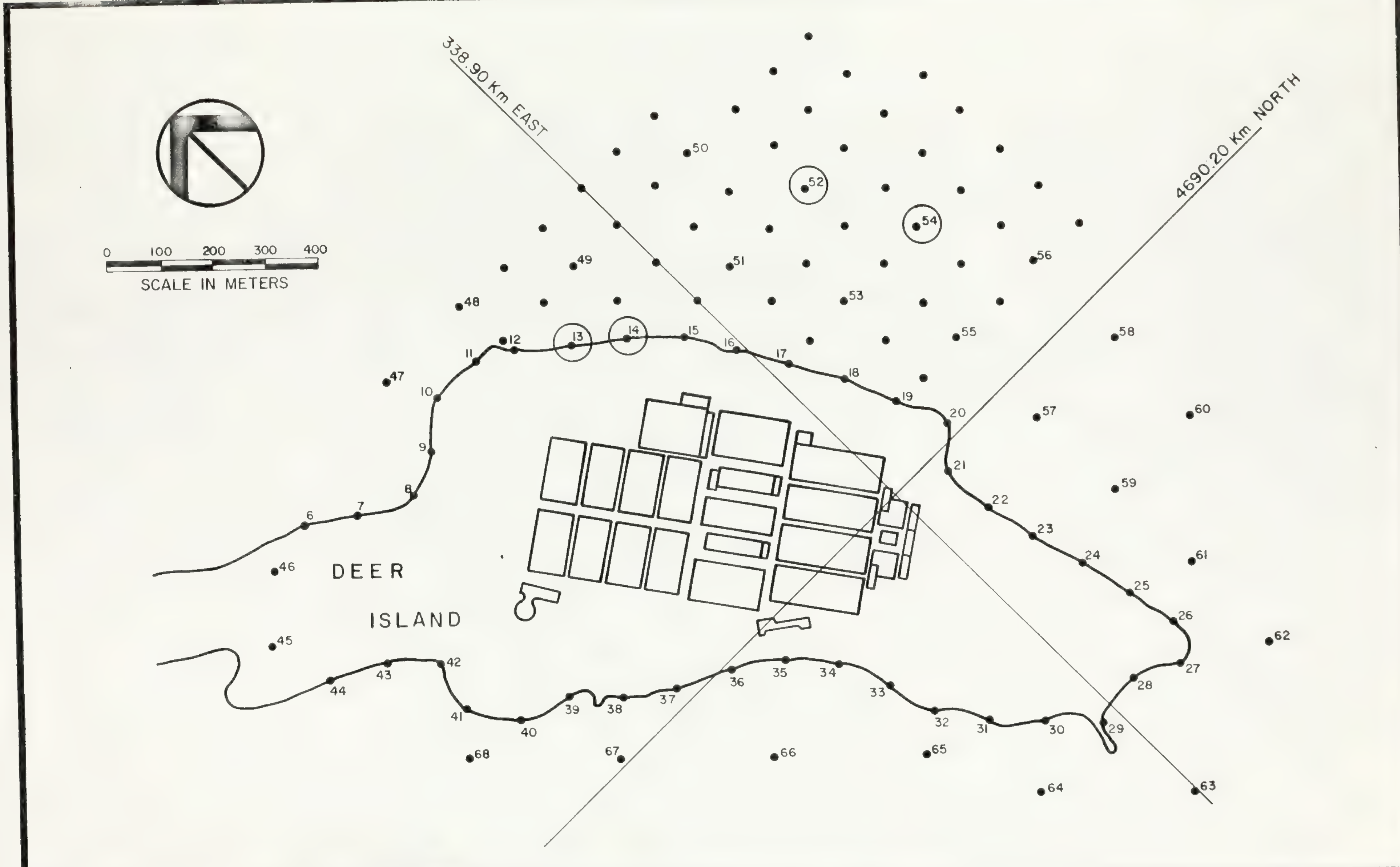

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FIGURE 7.5.6-2
100m RECEPTOR GRID USED IN
1985 ISCST MODEL CRITICAL DAY ANALYSIS
AND LOCATIONS OF MAXIMUM SOURCE GROUP IMPACTS

AMBIENT program. The figure can be used to illustrate the source/emission combinations of most importance to the detailed analysis. For example, 18 compounds produced maximum impacts at receptor No. 52 which, as shown previously in Figure 7.5.6-1, is also the maximum receptor for PC-1 and PC-2 impacts. The effect is that a large fraction of these compounds are released from the primary treatment system (see also Figure 7.3-1. Review of the emission results presented in Section 5 and summarized in Table 6.4-1 shows that many of the compounds are released in greater amounts from the primary treatment area than any other area of the plant. Similarly, receptor Nos. 13 and 14 were the locations of calculated maximums for 9 and 3 compounds, respectively. These receptors are very near the ISCST maximum receptor locations for AR-5 through AR-8 (secondary classifiers) and AR-9 (disinfection). As shown previously in Table 5.6-2, 12 individual compounds are emitted from these two treatment areas.

Of the odorous compounds listed in Table 7.6-1, methyl mercaptan shows a 24-hr concentration closer to the odor threshold than any other compound. To determine if the odor threshold for methyl mercaptan was exceeded, the 15-minute maximum concentration was selected from the AMBIENT Program for analysis. These 15-minute averages were derived in the AMBIENT Program from the 1-hour concentrations. For methyl mercaptan, the maximum 15-minute average concentration was estimated to be 0.99 $\mu g/m^3$. All other locations off-site were estimated to have concentrations lower than the maximum value of 0.99 $\mu g/m^3$, thus, assuring that no odor problems near the Deer Island facility should persist.

The conclusion of this ambient air quality impact assessment is that, for all VOCs except tetrachloroethene, the proposed secondary treatment facility for Deer Island will have inconsequential impacts on the local population in terms of ambient air quality impacts. Proposed treatment system covers, controls, and processes will be operated in such a manner that even under a worst-case scenario, the impacts will be within allowable air quality limitations at all locations acceptable to the population. At the more-easily accessible locations (neighborhood sites surrounding the facility), the impacts were found to be insignificant. The ambient air impacts will be even less at the shoreline receptors under the more routine flow and load regimes expected at the Deer Island treatment facility.

For tetrachloroethene, the AAL, which is based on a lifetime of exposure at the given concentration, will be exceeded roughly 10 times per year. The points where this occurs are offshore, east of Deer Island. Because tetrachloroethene is a common industrial solvent, its concentration in the wastewater, and thus its impact on ambient air levels, is susceptible to being decreased by industrial source control. Moreover, in plant design, special attention can be taken to decrease the potential for emitting tetrachloroethene, and for its removal from gas streams.

Secondary Treatment Facilities Plan

Volume III

Appendix F
Geotechnical

APPENDIX F

TECHNICAL MEMORANDUM OF ONSHORE GEOTECHNICAL INVESTIGATIONS AND GEOTECHNICAL DESIGN CRITERIA (DEER ISLAND AND NUT ISLAND)

1.0 INTRODUCTION

The purpose of this technical memorandum is to assess the geotechnical considerations regarding the construction of waste treatment facilities on Deer Island and Nut Island. Included is an inventory of previous studies conducted throughout the two islands, documentation of the Facilities Plan subsurface investigations, the results of the laboratory tests that characterize soil and rock properties from samples obtained during this recent investigation, and the geotechnical design criteria for the Facilities Plan. The report also includes a discussion of the general geology of Boston Harbor Islands, a listing of reference documents, and the boring logs from the Facilities Plan studies.

1.1 GENERAL GEOLOGY OF BOSTON HARBOR ISLANDS

The geology of the Boston Basin is treated extensively by LaForge (1932) and most recently by Billings (1976). The surficial geology of Deer Island and Nut Island comprises mostly Pleistocene sediments of glacial origin of varying thickness. The most prominent glacial features are the drumlins which consist of a till having a generally cohesive clayey/silt matrix containing granular pieces ranging from sand to boulder size. Cobbles, pebbles, and occasional boulders, along with sandy or gravelly layers, are often interbedded with the more homogenous materials. Some till directly overlies bedrock, while in other cases the till is underlain by older glacial sediments. In still others cases the till is submerged and buried or surrounded by later marine clays. Marine coastal forces have eroded, remolded, and redeposited these glacial sediments throughout the harbor area.

The bedrock geology of the islands consists primarily of slightly metamorphosed argillite, locally known as the Cambridge Formation. The argillite is most commonly observed to be very thinly bedded or laminated to occasionally nonbedded, very fine grained (generally silt to clay size), well indurated, and medium-hard to hard.

1.2 PREVIOUS INVESTIGATIONS AND INFORMATION

1.2.1 DEER ISLAND

In mid-1987 a series of 10 borings was performed in the southwest portion of Deer Island in order to support the marine facilities foundation design being done by C.E. Maguire Group Another recent geotechnical study involved the installation of groundwater observation wells,

This work which included installation of four wells in the area immediately south of the central drumlin feature, was completed in 1986 by Camp Dresser & McKee.
In 1981, Metcalf & Eddy, Inc. conducted extensive geotechnical investigations on Deer Island as part of the Nut Island Facilities Planning Project, Site Options Study (1983). Included in the subsurface investigations for this study were 7 borings (3 of which were established as groundwater observation wells) and 2 seismic refraction lines totalling 1,200 linear ft.

Earlier investigations on Deer Island date back as far as 1940. Several of these Metropolitan District Commission (MDC) contracts provide extensive subsurface boring data in the area of the existing plant and to the south of the central drumlin.

Figure F-1 illustrates the locations of numerous previous borings from the investigations described above.

1.2.2 NUT ISLAND

In 1986 C.E. Maguire completed 1 on-island boring and 4 near-shore borings as part of the planning and design effort for the marine facilities plan (1987). A 1981 Metcalf and Eddy field study included 1 on-island boring and 11 near-shore (tidal shallow) borings (1983). In 1980 Stone & Webster performed 1 boring on Nut Island as part of a geotechnical investigation for Boston Edison Edgar Power Station in Weymouth (1980). In addition, several MDC contracts dating from the 1940s provide subsurface boring data. The locations of several of these previous borings are shown on Figure F-2.

1.2.3 REFERENCE INFORMATION

Further information regarding bedrock is provided by various authors in describing MDC tunnelling projects in and around the Boston Harbor vicinity. Of particular interest are papers by Billings (1975) and Rahm (1962) which provide treatises on the geology of the North Metropolitan Relief Tunnel and the Main Drainage Tunnel, respectively. Both of the tunnels terminate at the existing Deer Island treatment facility. A listing of references annotated herein and additional noteworthy references are included in this Technical Memorandum.

1.3 FACILITIES PLAN FIELD EXPLORATIONS

1.3.1 DEER ISLAND

The Facilities Plan subsurface investigation consisted of 8 test borings and 4 test pits. Two borings were performed on Deer Island to define the soil profile and to determine the depth to bedrock and define the type of bedrock in the general vicinity of the proposed termination of the South System tunnel and the effluent outfall inlet shaft locations. These test borings were performed with a truck-mounted drill rig by New England Boring Contractors of Connecticut, Inc. between April 20 and April 24, 1987. The drilling was supervised and all samples were logged by SWEC personnel. At each boring, split spoon samples were taken at 5-ft depth

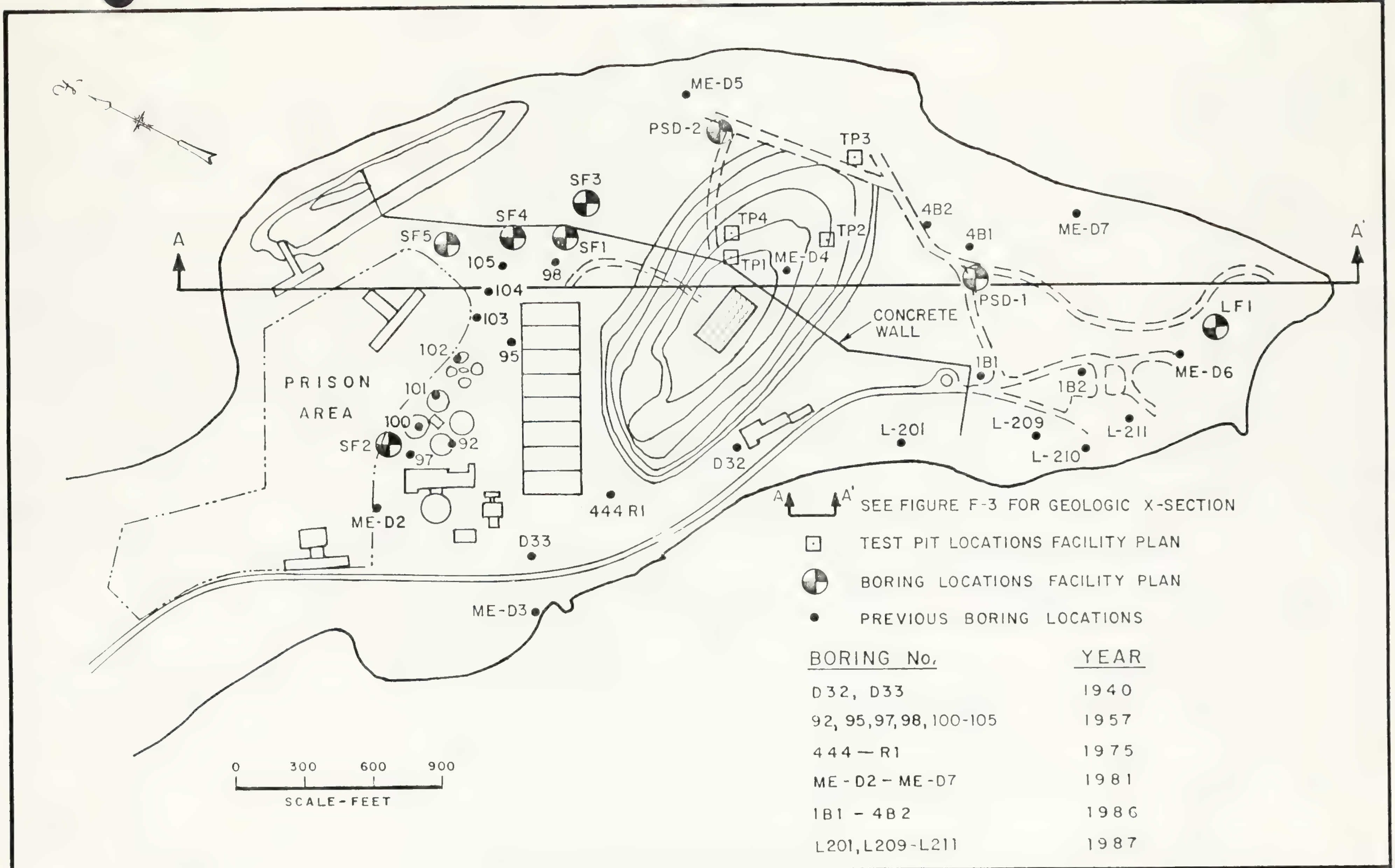

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FIGURE F-1

BORING LOCATION PLAN - DEER ISLAND

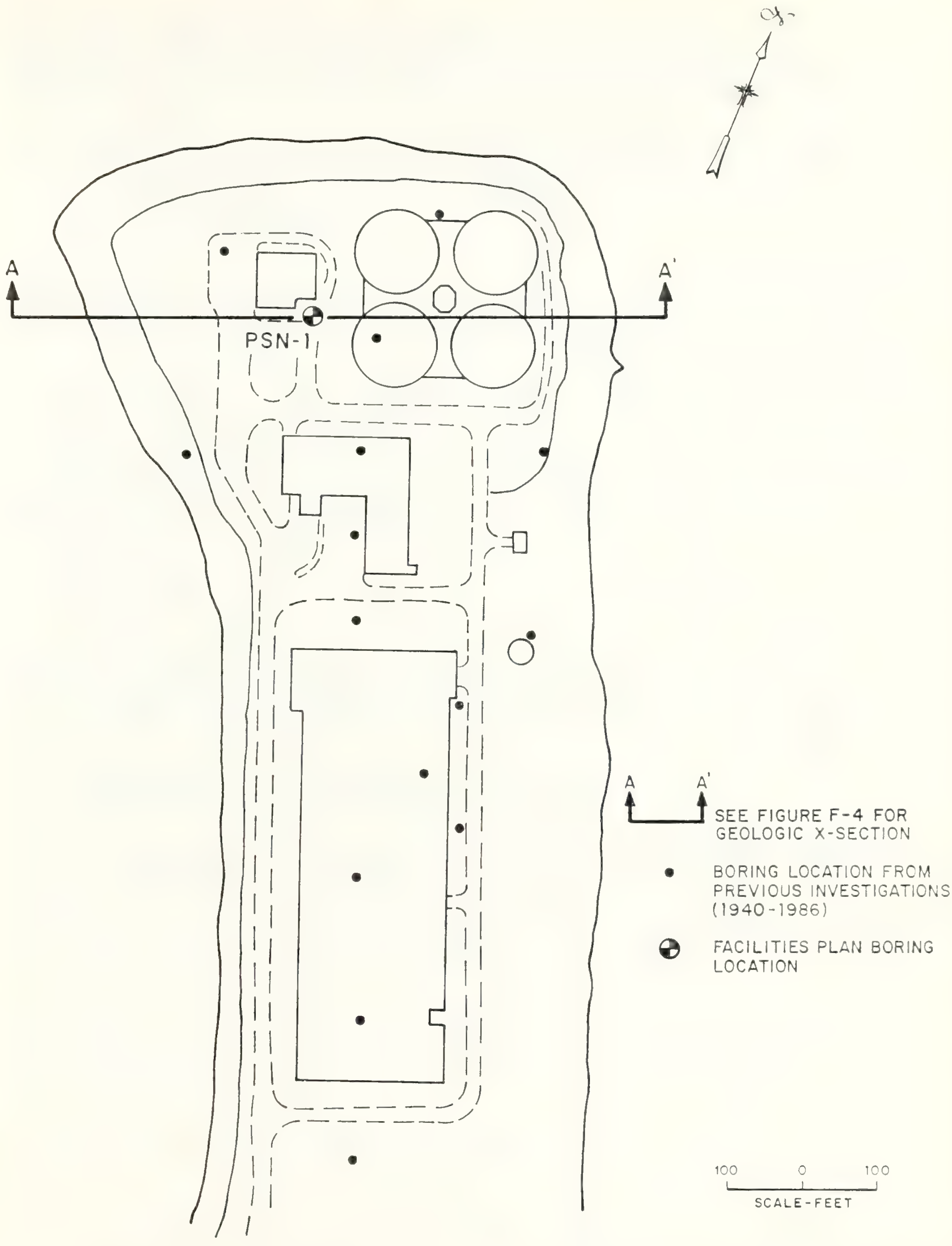

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FIGURE F-2
BORING LOCATION PLAN-NUT ISLAND

intervals for the initial 20 ft and then at 10 ft intervals to the top of bedrock. Approximately 10 ft of rock core was obtained at each location. Logs of these borings are attached to this Technical Memorandum. Figure F-1 illustrates the locations of the borings.

During the same period of time, 4 test pits up to 10 ft deep were excavated along the eastern flanks of the central drumlin. (Refer to Figure F-1 for test pit locations.) Test pit samples were evaluated to determine the suitability of the drumlin soils as fill materials and to aid in development of a soil disposal plan.

Between August 17 and 28, 1987, six additional borings were performed on Deer Island. At five of these locations, the purpose of the borings was to better define the areal extent and thickness of clay deposits known to exist to the north of the central drumlin in a portion of the area proposed for the secondary treatment facilities. One additional boring was performed near the southern end of the island in the area of the proposed grit and screenings landfill. These test borings were performed with a truck-mounted drill rig by Engineering Management Systems, Inc. of Rockland, Ma. The drilling was supervised and all samples were logged by SWEC personnel. Split spoon samples were taken at 2.5-ft to 5-ft intervals and 4 undisturbed samples of the clay soils were also recovered. Logs of these six borings are attached to this Technical Memorandum. Boring locations are shown on Figure F-1.

1.3.2 NUT ISLAND

One boring was performed on Nut Island on April 16-17, 1987, in the general vicinity of the proposed South System tunnel shaft inlet. This work was done in conjunction with, and in similar manner to, the two shaft location borings performed on Deer Island. A log of the boring is attached to this Technical Memorandum and the boring location is shown on Figure F-2.

1.4 LABORATORY TESTING (DEER ISLAND AND NUT ISLAND)

Testing of soil and rock samples was performed by the SWEC geotechnical laboratory. Gradation analyses were conducted on the Deer Island drumlin soils obtained from 4 test pits. All test results were quite similar, indicating fairly well graded materials with an average distribution of 35 percent gravel, 50 percent sand and 15 percent fines. Constant head permeability testing on compacted specimens from two test pits yielded results of 10^{-7} cm/sec.

The results of the laboratory testing on the Deer Island clay samples are presented in Table F-1. In summary, the consolidation tests on samples of the clay yielded an average preconsolidation pressure of 7.5 ksf and an average compression index of 0.4. The unconsolidated undrained compressive strength of the clay was on the order of 1-1.5 ksf.

The results of compression tests performed on selected samples of argillite rock core from Deer Island and Nut Island are as follows:

TABLE F-1

SUMMARY OF SOIL TESTS

INCREMENTAL CONSOLIDATION TEST

Boring No	Sample	Depth (ft)	Approx MDC Elev. (ft)	Specimen Diameter (in)	Specimen Height (in)	Initial Water cont.(%)	Dry Unit Weight (PCF)	Initial Void Ratio	Max. Past Press. (KSF)	Compression Index
SF1	11	46	86	2.5	0.75	39.6	84.5	1.00	8.5	0.37
SF3	14	66	73	2.5	0.75	42.7	83.3	1.02	6.5	0.41

OVERCONSOLIDATION RATIO	RECOMPRESSION INDEX
2.2	0.06
1.2	0.07

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST

Boring No	Sample	Depth (ft)	Approx MDC Elev. (ft)	Specimen Diameter (in)	Specimen Height (in)	Water Content (%)	Rate of Strain (% Min)	Confining Pressure (KSF)	Axial Stress (KSF)	Axial Strain (%)
SF1	11	46	86	1.40	3.50	38.7	0.4	3.6	1.52	3.5
SF3	14	66	73	1.40	3.47	41.8	0.4	3.6	1.04	4

Sample No.	Depth (ft)	Axial Compressive Strength (psi)
PSD1 (Deer Island)	95.1	16,130
PSD2 (Deer Island)	121.4	9,730
PSN1 (Nut Island)	104.0	17,820

These results may be compared with similar testing performed earlier for the marine portion of this investigation (avg 11,000 psi, SWEC, 1987) and from testing by others (avg 15,000-19,000 psi, Metcalf and Eddy, 1983; SWEC, 1980).

1.5 DISCUSSION OF RESULTS

1.5.1 DEER ISLAND

The dominant topographic and geologic feature on Deer Island is the central drumlin. Another smaller, partially eroded drumlin is located at the north shore of the island and the remnant of a third drumlin is barely perceptible at the southernmost tip. The till comprising the drumlins is generally a dense to very dense mixture of clay, silt, sand, gravel, and boulders and approaches a maximum thickness of 200 ft at the central drumlin. The proportion of coarse to fine grained material is typically highly variable and irregularly distributed throughout the drumlins.

Flanking the slopes and between the drumlins are deposits of marine clays that are often overlain by glacial drift or outwash. The marine deposits consist of a gray silty clay (glacial rock flow) that typically is moderately plastic and ranges in consistency from soft to stiff. These clays vary in thickness up to 50 ft. The zone of greatest clay thickness is located approximately 500 ft north of the central drumlin traversing the site in an east-west direction. The width of this clay zone is several hundred feet with the greatest thickness along a line passing through the existing digesters and extending eastward toward the shoreline beyond the northeastern corner of the existing sedimentation basins. Other zones of extensive clay thickness are south and west of the central drumlin where up to 30 ft of clay has been observed. Sand and gravel outwash up to 20 ft thick often overlies the clays.

Organic silts, peat, and muck have been observed in low-lying areas between the drumlins in areas that generally coincide with the distribution of marine clay deposits where groundwater drainage would have been limited. From previous borings on Deer Island the peat deposits are most evident in the vicinity of the existing treatment facility north of the central drumlin, and vary in thickness up to 13 ft.

The presence of soil fill materials has been documented in the area of the existing treatment facility, to the east of the plant, and along roadways, near the western shore of Deer Island. Zones of grit and screenings exist across the southern one-third of the island. Excavation spoil or "tunnel muck" from previous shaft excavations has also been placed along the shoreline immediately to the west of the treatment facility.

Based on the numerous borings and the limited seismic work on Deer Island, the topographic relief of the bedrock surface varies from el +35 beneath the central drumlin to el -40 along the western shore of the island. The bedrock elevations at borings PSD-1 and PSD-2 are el +35 and el +21, respectively.

The bedrock observed in borings from this investigation is characterized as gray argillite and is generally very thinly bedded. Bedding is distinguished by alternating light and dark gray bands dipping at 25° to 50° from horizontal. Bedding plane joints or partings are very evident. The condition of the rock observed was generally fresh to slightly weathered with the engineering rock quality designated as "good" for the upper 10 feet.

Figure F-3 is a generalized north-south cross-section of the Deer Island geology. Based on interpretations from the results of the field studies, the extents and thicknesses of the various geologic units discussed above are presented in approximate form.

No surficial streams, swamps, or ponds nor groundwater seeps or springs have been observed on Deer Island. A few groundwater observation wells were established during an earlier investigation program in the low-lying areas adjacent to the drumlins. Water levels varied between el 108 to 114 (approximately 8 to 11 ft below ground surface). At the central drumlin there appears to be a perched water table that follows the contour of the drumlin at depths varying between 10 to 30 ft below the prevailing ground surface. Storage and recharge capacities are expected to be limited due to the dense and impervious nature of the till.

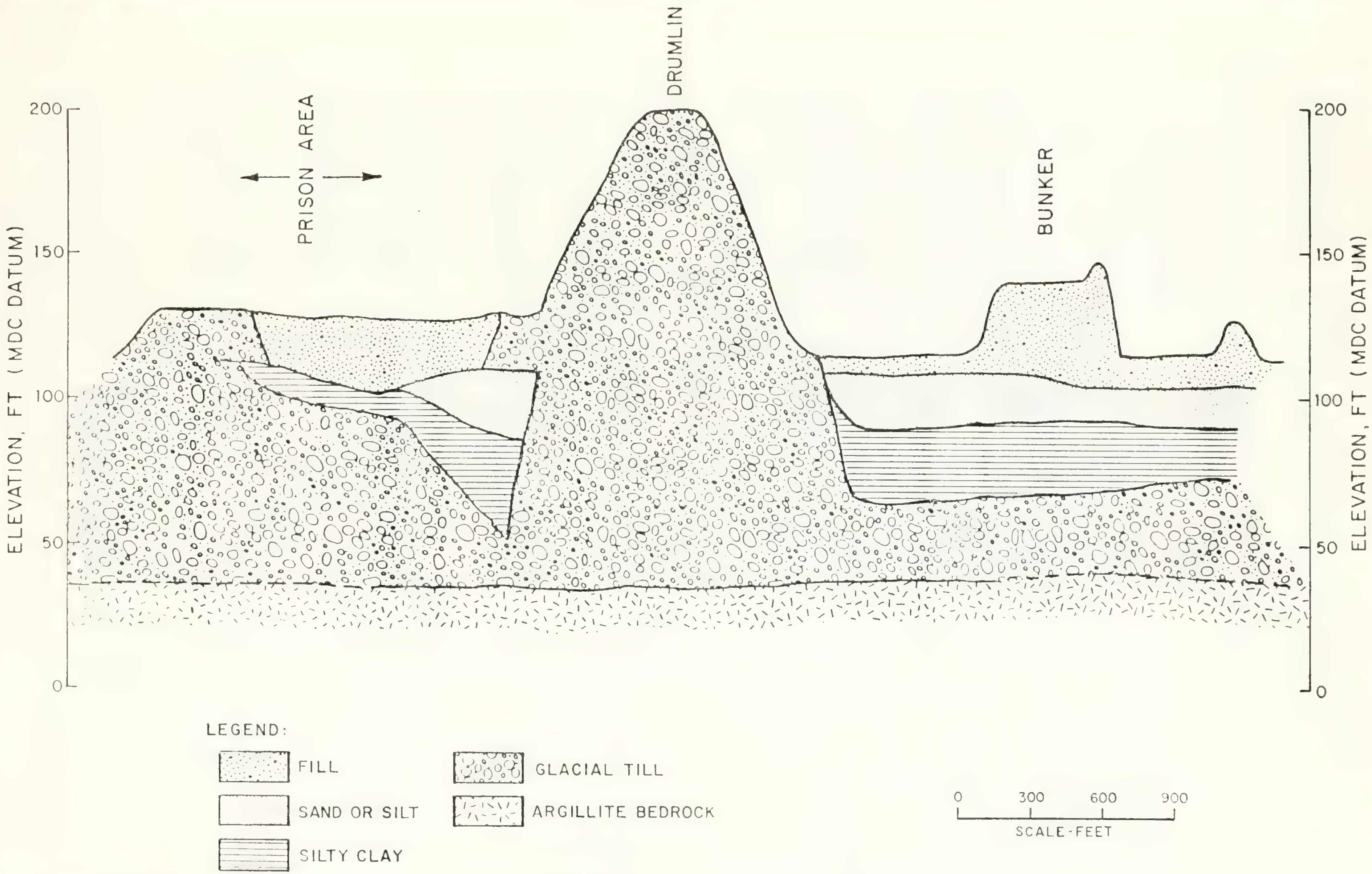
1.5.2 NUT ISLAND

Nut Island is a partially eroded drumlin island that is connected to a larger drumlin on the mainland (Hough's Neck) by a man-made causeway. Much of the fill material used to raise the causeway for the sedimentation tanks was taken from the drumlin at the north end of the peninsula (Metcalf and Eddy, 1983).

Nut Island itself is composed primarily of till as described at Deer Island. Marine clays or organic materials are found to a limited extent in areas flanking the drumlin. Previous boreholes along the area of the causeway and in the vicinity of the existing sedimentation tanks penetrated a 2-ft-thick layer of peat overlying the marine clays and underlying fill material. The peat layer appears to be limited to the east-central portion of the peninsula (Metcalf and Eddy, 1983).

As observed in the boring from this investigation (PSN-1), taken on the remnant of the original Nut Island drumlin, approximately 95 ft of till was encountered and is generally characterized as gravelly, sandy clay. The bedrock surface at this location is at el +36

The upper 10 ft of bedrock was sampled and is characterized as dark gray argillite, very thinly bedded at 45° from horizontal. Major fracture orientations were 10°-15°, 45°, and nearly vertical. Many of the fractures have been rehealed by calcite and quartz. The condition of



MASSACHUSETTS WATER RESOURCES AUTHORITY	FIGURE F-3 DEER ISLAND GEOLOGIC CROSS SECTION A-A' (SEE FIGURE F-1)

the surficial rock may be described as fresh to slightly weathered with a poor engineering rock quality designation.

An east-west cross-section of the geology near the northern end of Nut Island is shown on Figure F-4.

1.6 DESIGN CRITERIA

The proposed treatment plant will be located in the north-central portion of the Deer Island covering an area 2,000 ft north-south by 1,500 ft east-west. Along the north, south and east sides and along a portion of the west side of the island, landforms will be created from on-site fill materials and/or tunnel spoils to act as visual and/or noise barriers. The effluent outfall inlet shaft will be installed in the northeast portion of the island and the South System pump station shaft is proposed for the south central island area. To the southwest of the central drumlin the bulkhead will be constructed for the pier facility. The residuals handling area will be located immediately south of the drumlin and the grit and screenings landfill will be located near the southern tip of the island.

The proposed installation on Nut Island will consist of a grit handling facility and the South System tunnel inlet shaft. These facilities will be located near the northern end of the island in the vicinity of the existing digesters.

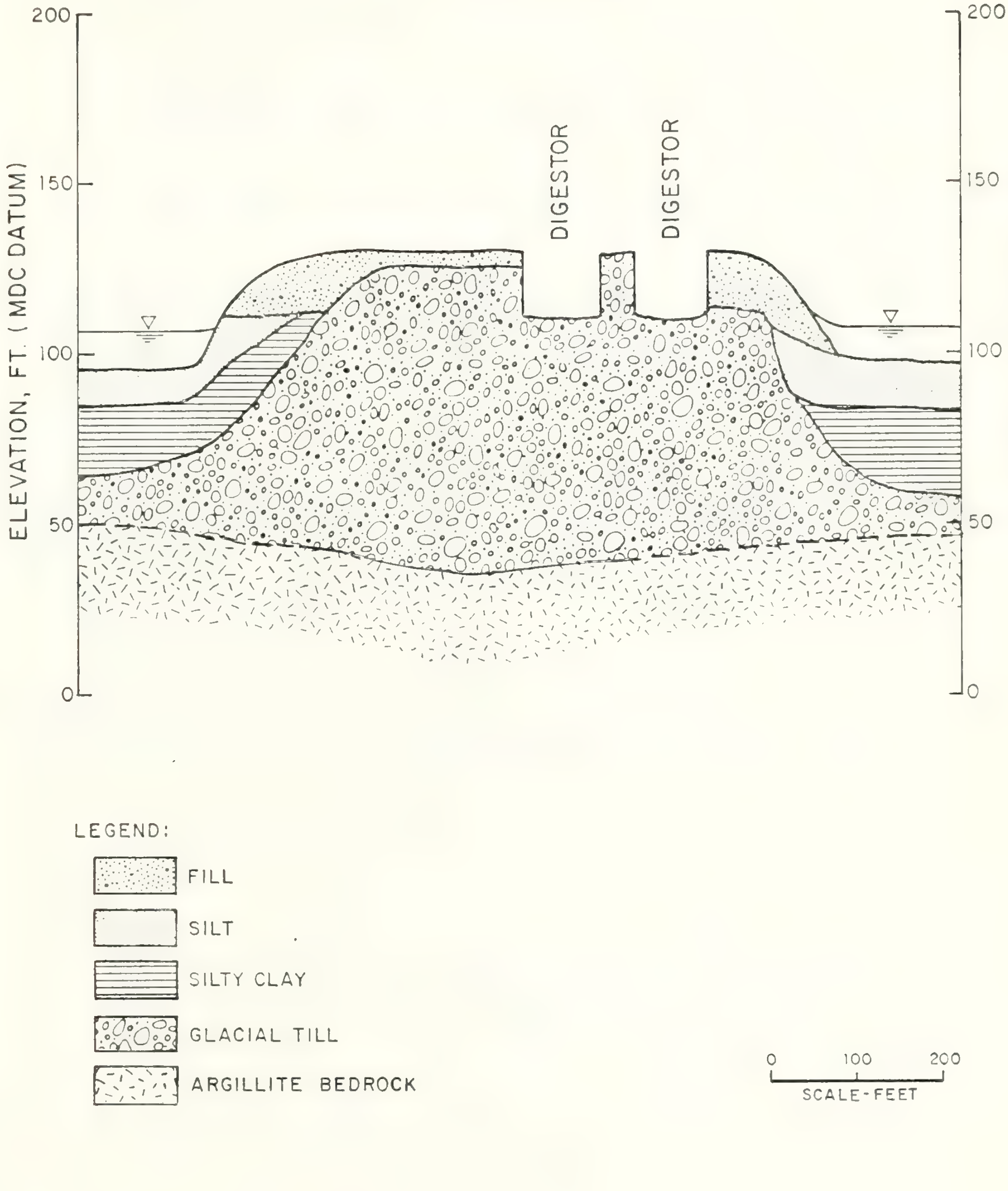
1.6.1 PLANT FOUNDATIONS

Deer Island

The majority of the plant foundations on Deer Island will be spread footings or mat foundations founded on glacial till. These soils have adequate bearing capacity and will not consolidate excessively under structural loads in the range of 3-5 kips/ft^2. However, the working surface of the drumlin soils can be disturbed by construction activities and rainfall. Therefore, once the foundation grade has been attained it will be necessary to place a construction working surface consisting of a 9"-12" layer of sand/gravel or crushed stone.

There are portions of the proposed facility that will be founded over some existing fills, limited extents of organic material, and extensive clay deposits. Laboratory consolidation testing of the clay soils and settlement analysis based on preliminary structural load information indicate that 2"-3" of settlement may occur as a result of consolidation of the clays. Portions of both the proposed grit handling facility and secondary clarifiers are to be located in areas where clay has been encountered.

Until further field and laboratory studies more accurately define the extent and nature of these soils and a more extensive analytical program is carried out during the design phase of the project, it is recommended that pile foundations be designated for the following structures:



MASSACHUSETTS WATER RESOURCES AUTHORITY

FIGURE F-4
NUT ISLAND GEOLOGIC CROSS SECTION A-A'
(SEE FIGURE F-2)

- o Grit facilities and adjacent structures (located south of the primary clarifiers).
- o The northern one-third of the secondary clarifiers.
- o Power facility (located north of the North Main Pumping Station).
- o North System force main (between existing North Pump Station and proposed grit facility).
- o Residuals handling facilities (to be determined by Residuals Management Facilities Plan)

Piles penetrating at least 10 ft into the dense glacial till can be designed for capacities of up to 120 tons. Pre-augering of the holes will aid the installation process and mitigate a portion of the noise associated with pile driving.

Nut Island

The grit handling facility foundations will be spread footings or mats founded on glacial till. As in the case of the Deer Island till, a stone or gravel working surface will be required to prevent disturbance of the excavated till surfaces on Nut Island due to the effects of construction equipment.

1.6.2 SITE DEWATERING (DEER ISLAND AND NUT ISLAND)

Dewatering of most excavations will be handled with collection of any minor seepage by open sumps. If any excavations that are in granular soils extend well below el 110 ft, a well point or deep well system may be required to control seepage into the excavation.

1.6.3 FILL AND BACKFILL MATERIALS

Deer Island

The major portion of the excavated soil material that will be available as fill to raise site grades and as common backfill is the glacial till composing the central drumlin. The till is a very heterogeneous material with significant percentages of gravel, sand, and fines. Gradation analysis on test pit samples indicate the material is a gravelly silty sand (gravel percentage ranging between 30-40 percent and silt/clay percentage from 15-30 percent). In general, these drumlin soils will be suitable as a fill to raise the site grade and for common fill providing that proper placement and compaction procedures are followed. However, the degree of difficulty in handling, placing, and compacting a widely variable graded till will be greater than that for a clean granular fill. For example, the till soils will be quite sensitive to changes in moisture content; as a result, during prolonged dry periods or rainfall, the time and effort involved in proper fill placement will be significantly increased

There will be applications immediately adjacent to and below structures and buried pipes where a clean granular fill will be required. In these cases, a sand/gravel or crushed stone must be imported from off-site unless the inter-island or outfall tunnel spoils of argillite rock are available and determined to be suitable as backfill or bedding. Typically, the predominant particle sizes of spoils produced by tunnel boring machines are in the sand and gravel size range with maximum sizes on the order of 3-5 inches. A limited amount of crushing and/or screening may well qualify these spoils as fill suitable for certain applications.

Nut Island

The proposed grit handling facility and inter-island tunnel shaft will be constructed in the vicinity of the existing digesters so that there will be little or no need for fill to raise the site grade. Backfill requirements will best be met by an imported granular material, or through use of excess excavation material from Deer Island.

1.6.4 LANDFORMS

Deer Island

The perimeter landforms will be created from excess excavation materials mainly by excavation of the glacial till from the central drumlin. Additional materials will be available from demolitions of existing structures, from excavations of sand, clay or silt for various structures, and from the South System and outfall shaft/tunnel excavations. In general, the only restrictions on the type of materials not suitable for landforms would be based on environmental criteria. Placement and compaction requirements for landform materials, while not particularly stringent, will be developed as part of the design to insure against excessive settlement, slumping, or other unstable conditions. In general, finished side slopes will be maintained at a maximum slope of 2 horizontal: 1 vertical in order to assure stability.

Within the southern landform, a secured landfill will be developed for existing Deer Island grit and screenings. The requirements of the Massachusetts Department of Environmental Quality Engineering (DEQE) will dictate the actual design including, as a minimum, a double liner and a low permeability cap layer. The soil boring performed in the area of the proposed landfill indicates that the underlying clay or till is medium-stiff to hard and as such should not undergo sufficient consolidation to endanger the integrity of the landfill liners.

Nut Island

Landforms are proposed for portions of the perimeter of the head of Nut Island and along the long axis of the causeway. Suitable on-site fill materials will include soils excavated for the proposed grit handling facility, tunnel shaft spoils, and demolition debris. Additional material in the form of excess drumlin excavation or tunnel spoils will be available from Deer Island as landform materials. In order to ensure stability, a 2:1 (H:V) maximum slope limitation will be maintained. If landforms are constructed over extensive zones of soft

organic or clay soils, the construction sequence may have to be carefully controlled and monitored to maintain stability of these weak soils.

1.6.5 TUNNEL ACCESS SHAFTS (DEER ISLAND AND NUT ISLAND)

The vertical shafts will penetrate approximately 100 ft of post-glacial and glacial till soils. A lateral support system, such as soldier piles/lagging or casing, will be installed as the excavation progresses. While some groundwater will be likely to enter the excavation, the fine-grained nature of the greater portion of the soils will restrict the quantity of flow. For the most part, groundwater control will be accomplished by collection at sump locations.

Extension of the shaft into the argillite bedrock will be by conventional drill and blast techniques from the soil/bedrock interface to the designated tunnel depth. As in the case of the overlying soil, water seepage control will be maintained by localized sumping.

The design earth pressure coefficients and hydrostatic loadings on the shafts will be established for each shaft during the design phase of the project based on further field studies and laboratory testing.

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SITE	DEER ISLAND, MASSACHUSETTS	J.O. NO.	16499.27
BORING NO.	PSD-1	SHEET	1 OF 3
COORDINATES	N491,620 E747,040	GROUND ELEV. (1)	APPROX. 116 FT
INCLINATION	VERTICAL	BEARING	
INSPECTOR	T. L. ANNARATONE		
DATE: START / FINISH	4-21-87 / 4-22-87	CONTRACTOR / DRILLER	NEW ENGLAND BORING/RAMSDELL
STATIC GROUNDWATER DEPTH / DATE	4.5 (FT) / 4-22-87	DRILL RIG TYPE	MOBILE DRILL - B-61
DEPTH TO BEDROCK	89.5 (FT)	TOTAL DEPTH DRILLED	100 (FT)

METHODS:

DRILLING SOIL: TRICONE ROLLER BIT, CASING, WATER

SAMPLING SOIL: SPLIT SPOON

DRILLING ROCK: NWD4 CORE

SPECIAL TESTING OR INSTRUMENTATION:

COMMENTS:

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
	5	SS	1	4-6-5 (9")	11	SP	SAND, POORLY GRADED, MEDIUM TO COARSE, 10% GRAVEL TO 0.25IN. MAXIMUM, 5-10% NONPLASTIC FINES, BROWN GRAY
	10	SS	2	10-11-18 (16")	28	SP GP	SAND, SIMILAR TO ABOVE, EXCEPT COARSER AND ORGANIC (TOP 9") GRAVEL, 1 IN. MAXIMUM, 5-10% NONPLASTIC FINES, GRAY (BOTTOM 7")
	15	SS	3	3-3-3 (12")	6	SM	SANDY SILT, 10-15% FINE SAND, NONPLASTIC, SOME SHELL FRAGMENTS, GRAY
	20	SS	4	1-1-2-4 (14")	3	CL	SANDY CLAY, MODERATELY PLASTIC, 20-25% FINE SAND, SOFT, SOME SHELL FRAGMENTS AND ORGANIC MATERIAL PRESENT AS SAND-SIZED PARTICLES, DARK GRAY
	25						
	30						

LEGEND / NOTES

1. DATUM IS MDC SEWER DATUM (MDC = USGS + 105.62 FT)
2. ▽ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". * INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT.
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. SS = SPLIT SPOON

BORING LOG

DEER ISLAND SECONDARY TREATMENT FACILITY

STONE & WEBSTER ENG. CORP
SKETCH No.

APPROVED	DATE	BORING NO.	SHEET
WE Killer		PSD-1	1 OF 3

BORING NO. PSD-1

SHEET 2 OF 3

SITE DEER ISLAND, MASSACHUSETTS J.O. NO. 16499.27

ELEVATION (FEET) (1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	5	7-9-10 (18")	19	CL	SANDY CLAY MODERATELY PLASTIC, 15-20% FINE SAND, STIFF, SOME GRAVEL TO 0.25 IN. MAXIMUM, GRAY WITH BROWN MOTTLING.
	35						
	40	SS	6	2-2-3 (18")	5	CL	CLAY, MODERATELY PLASTIC, LESS THAN 5% SAND, FIRM, GRAY GREEN
	45						
	50	SS	7	2-3-3 (18")	6	CL	CLAY, MODERATELY PLASTIC, LESS THAN 5% SAND, FIRM, GRAY GREEN
	55						
	60	SS	8	23-23-20 (4")	43	SC	CLAYEY SAND, POORLY GRADED, MEDIUM TO COARSE, MOSTLY COARSE, SOME GRAVEL TO 0.25 IN., 10-15% SLIGHTLY PLASTIC FINES, GRAY
	65						
	70	SS	9	13-15-16 (9")	31	CL	SANDY CLAY, MODERATELY PLASTIC, 10-15% GRAVEL TO 0.3 IN. MAXIMUM, 25-30% COARSE TO FINE SAND, SOME GRAVEL TO 1 IN. MAXIMUM, GRAY GREEN WITH YELLOW BROWN MOTTLING
	75						
	80	SS	10	19-24-31 (0)	55	-	NO RECOVERY
	85	[illegible]	11	[illegible]	[illegible]	[illegible]	SANDY CLAY, MODERATLY PLASTIC, 10-15% GRAVEL to 0.3 IN. MAXIMUM, [illegible] COARSE TO FINE SAND, SOME GRAVEL TO 1 IN. MAXIMUM, GRAY GREEN WITH YELLOW BROWN MOTTLING
	90						

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.

STONE & WEBSTER ENG. CORP. SKETCH No.

APPROVED WEKilian

DATE

BORING NO. PSD-1

SHEET 2 OF 3

BORING NO. PSD-1

SHEET 3 OF 3

SITE DEER ISLAND, MASSACHUSETTS J.O. NO. 16499.2[illegible]

ELEVATION (FEET) (1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
							TOP OF ROCK @ 89.5
		NX	1	98/72			MED. TO DK. GRAY ARGILLITE, VERY THIN BEDDED., LAM. FAINT @ 45-[illegible], FRESH TO SL. WX., MOD. HARD TO HARD, FREQUENT VEINLETS OF CALCITE (UP TO 1/16" THICK) SUBPARALLEL TO PARALLEL WITH BEDDING, JOINTING IS CLOSELY SPACED, OCCASIONAL CALCAREOUS BEDS UP TO 1/2 IN. THICK. 90.4 FT JT @ 50° SMOOTH, FeO STAIN, PARRALLEL TO BED, CROSS JT @ 60°, SMOOTH FeO STAIN. 90.8 FT CROSS JTS AS ABOVE EXCEPT NO FeO STAIN, SL. CALCAREOUS 91.6 FT-92.0 FT JT. SUBVERT, SMOOTH, SL. CALCAREOUS
	95	NX	2	100/86			91.9 FT @ 45°(PERPENDICULAR TO BED),SMOOTH, FRESH 93.4 FT @ 50°, CALCITE FILLED 96.8 FT JT. @ 50%, CALCITE FILLED, PARALLEL TO BED, SLIGHTLY [illegible], IRREGULAR
	100						END OF BORING @ 100 FT

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.

STONE & WEBSTER ENG. CORP. SKETCH No.

APPROVED	DATE	BORING NO.	SHEET
W.E. Kilkey		PSD-1	3 OF 3

SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 16499.27

BORING NO. PSD-2

SHEET 1 OF 3

COORDINATES N492,810 E747,130 GROUND ELEV. (1) APPROX. 136 FT

INCLINATION VERTICAL BEARING INSPECTOR T. L. ANNARATONE

DATE : START / FINISH 4-22-87 / 4-24-87 CONTRACTOR / DRILLER NEW ENGLAND BORING/RAMSDELL

STATIC GROUNDWATER DEPTH / DATE 10 (FT) / 4-24-87 DRILL RIG TYPE MOBILE DRILL - B-61

DEPTH TO BEDROCK 115 (FT) TOTAL DEPTH DRILLED 126 (FT)

METHODS :

DRILLING SOIL TRICONE ROLLER BIT, WATER (DRILLING MUD AFTER 50 FT)

SAMPLING SOIL SPLIT SPOON

DRILLING ROCK NWD4 CORE

SPECIAL TESTING OR INSTRUMENTATION

COMMENTS

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
	5	SS	1	7-12-18 (17")	30	CL	SANDY CLAY, MODERATELY PLASTIC, 25-30% COARSE TO FINE, MOSTLY MEDIUM AND FINE, SOME GRAVEL TO 0.5 IN., YELLOW BROWN MOTTLED WITH GRAY
	10	SS	2	9-21-50 (18")	71	CL	SANDY CLAY, SIMILAR TO ABOVE, MORE GRAVEL TO 1 IN., MAXIMUM
	15	SS	3	25-20-26 (14")	46	CL	SANDY CLAY, MODERATELY PLASTIC, HARD, 15-20% GRAVEL TO 1.5 IN. MAXIMUM, 25-30% COARSE TO FINE SAND, GRAY WITH YELLOW MOTTLING
	20	SS	4	19-19-28 (8")	47	CL	SANDY CLAY, SLIGHTLY PLASTIC, HARD, 15-20% COARSE TO FINE SAND, SOME GRAVEL [illegible] IN. MAXIMUM, GRAY WITH YELLOW MOTTLING
	25						
	30						

LEGEND / NOTES

1. DATUM IS MDC SEWER DATUM (MDC = USGS + 105.62 FT)
2. ▽ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140 lb. HAMMER FALLING 30". * INDICATES USE OF 300 lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY.
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT.
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. SS = SPLIT SPOON

BORING LOG

DEER ISLAND SECONDARY TREATMENT FACILITY

MWRA

STONE & WEBSTER ENG. CORP
SKETCH No.

APPROVED	DATE	BORING NO.	SHEET
W.E. Keller		PSD-2	1 OF 3

BORING NO.	PSD-2
SHEET 2 OF	3

SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 16499.27

ELEVATION (FEET) (1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	5	14-19-21 (18")	40	CL	SANDY CLAY, MODERATELY PLASTIC, HARD, 10-15% COARSE TO FINE SAND, MOSTLY COARSE, SOME GRAVEL TO 1 IN. MAXIMUM, LIGHT GRAY
	35						
	40	SS	6	13-40-26 (14")	66	CL	SANDY CLAY, SIMILAR TO ABOVE, EXCEPT MORE GRAVEL, MAXIMUM SIZE 1.5 IN., LIGHT GRAY
	45						
	50	SS	7	12-13-21 (13")	34	CL	SANDY CLAY, MODERATELY PLASTIC, VERY STIFF, 15-20% GRAVEL TO 1 IN., 25-30% COARSE TO FINE SAND, GREEN GRAY
	55						
	60	SS	8	22-18-26 (14")	44	CL	SANDY CLAY, SIMILAR TO ABOVE, EXCEPT COARSER, WITH ROCK FRAGMENTS TO 1.5 IN., GREEN GRAY
	65						(LAYER OF COBBLES AT 68 FT)
	70	SS	9	10-17-22 (18")	39	SC	CLAYEY SAND, WIDELY GRADED, 15-20% GRAVEL TO 0.3 IN. MAXIMUM, COARSE TO FINE SAND, 20-25% SLIGHTLY PLASTIC FINES, GREEN GRAY
	75						
	80	SS	10	19-22-29 (15")	51	SC	CLAYEY SAND, WIDELY GRADED, COARSE TO FINE, MOSTLY COARSE, SOME GRAVEL TO 1 IN., 10-15%, SLIGHTLY PLASTIC FINES, FRESH ARGILLITE ROCK FRAGMENTS, GREEN GRAY
	85						
	90						

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.	STONE & WEBSTER ENG. CORP. SKETCH No.	APPROVED	DATE	BORING NO.	SHEET
		2 Etiln		PSD-2	2 OF 3

BORING NO. PSD-2

SHEET 3 OF 3

SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 16499.27

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	11	19-18-35 (16")	53	CL	SANDY CLAY, MODERATELY PLASTIC, 10-15% GRAVEL to 0.3 IN. MAXIMUM, COARSE TO FINE SAND, GREEN GRAY
	95						
	100	SS	12	84-42-46 (18")	88	GC	CLAYEY GRAVEL, COARSE TO FINE, MOSTLY COARSE, SUBROUNDED AND ANGULAR TO 1.5 IN. MAXIMUM ARGILLITE FRAGMENTS, 15-20% SLIGHTLY PLASTIC FINES, GREEN GRAY
	105						
	110						TOP OF ROCK @ 115
	115	NX	1	100/?			MED TO DK GRAY ARGILLITE VERY THINLY BEDDED (LAM). @ 45°-50°, FRESH, MOD HARD TO HARD, JOINTS (PARTINGS) @ 1/2 IN. TO 3 IN. SPACING, SMOOTH, MOSTLY FRESH TO CALCITE FILLED, OCCAS. CALC. VEINLET ACROSS BEDDING, OCCAS. LIGHT COLOR BEDS ARE CALCAREOUS.
	120	NX	2	100/?			
	125						END OF BORING @ 126.0 FT.
	130						

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.	STONE & WEBSTER ENG. CORP. SKETCH No.	APPROVED	DATE	BORING NO.	SHEET
				PSD-2	3 OF 3

SITE: DEER ISLAND SECONDARY TREATMENT FACILITY — J.O. NO. 16499.27

BORING NO. SF-1 — SHEET 1 OF 3

COORDINATES: N493,280 E746,410 — GROUND ELEV. (1) APPROX. +132

INCLINATION: VERTICAL — BEARING: - — INSPECTOR: HASAN ABEDI

DATE: START / FINISH: 8/17/87 / 8/20/87 — CONTRACTOR / DRILLER: EMS/CHARLES REIL

STATIC GROUNDWATER DEPTH / DATE: 20 (FT) / 8/21/87 — DRILL RIG TYPE: MOBILE B-57

DEPTH TO BEDROCK: (FT) — TOTAL DEPTH DRILLED: 92 (FT)

METHODS:

DRILLING SOIL: ROLLER BIT TO 90 FT., CASING DRIVEN TO 35 FT., WATER

SAMPLING SOIL: SPLIT SPOON AT 5 FT INTERVALS TO 92 FT. SHELBY TUBE SAMPLES AT 37.5 FT and 45.0 FT.

DRILLING ROCK: NONE

SPECIAL TESTING OR INSTRUMENTATION:

COMMENTS:

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
	2						FILL: SANDY GRAVEL, 20-40% BOLDERS AND COBBLES TO 24 IN. MAXIMUM, 20-40% SAND, 5-10% FINES, LIGHT BROWN.
							FILL: SANDY SILT, SLIGHTLY PLASTIC, 5-10% GRAVEL TO 1.5 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, BROWNISH GRAY, SOME ROOTS AND ORGANIC MATERIAL.
	5	SS	1	8 - 8 - 7 (11 IN.)	15		FILL: SANDY SILT, SLIGHTLY PLASTIC, 10-20% MEDIUM TO FINE SAND, STIFF, BROWNISH GRAY.
	10	SS	2	6 - 3 - 3 (4 IN.)	6		FILL: SANDY SILT, MODERATELY PLASTIC, 10-15% GRAVEL TO 0.5 IN. MAXIMUM, 10-15% COARSE TO FINE SAND, FIRM, BROWNISH GRAY. NOTE: LOST SAMPLE; OVERDROVE SECOND ATTEMPT TO INCREASE RECOVERY
	15	SS	3	2 - 3 - 4 - 4 (10 IN.)	7		FILL: SANDY SILT, SAME AS ABOVE. BOTTOM 3 IN. TOP SOIL WITH MANY ROOTS.
							(BOTTOM OF FILL AT APPROXIMATELY 17.5 FT)
	20	SS	4	13-10-10 (10 IN.)	20	SM-ML	SILTY SAND, WIDELY GRADED, 5-10% GRAVEL TO 1.5 IN. MAXIMUM, COARSE TO FINE SAND, MOSTLY FINE, 15-20% SLIGHTLY PLASTIC FINES, BROWNISH GRAY
	25	SS	5	20-19-27 (13 IN.)	46	SM-ML	SILTY SAND, SIMILAR TO ABOVE, EXCEPT SOME DARK REDDISH BROWN INCLUSIONS
	30						

LEGEND / NOTES

1. DATUM IS MDC SEWER DATUM (MDC = USGS + 105.62 FT)
2. ∇ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". * INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY.
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT.
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. SS = SPLIT SPOON
8. US = UNDISTURBED SAMPLE

BORING LOG

DEER ISLAND SECONDARY TREATMENT FACILITY

MWRA

STONE & WEBSTER ENG. CORP
SKETCH No.

APPROVED	DATE	BORING NO.	SHEET
[illegible signature]		SF-1	1 OF 3

BORING NO.	SF-1
SHEET 2 OF	3

SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 15499.27

ELEVATION (FEET) (1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	6	12-14-17 (8 IN.)	31	ML SM	SANDY SILT, SLIGHTLY PLASTIC, 5-10% GRAVEL TO 0.3 IN. MAXIMUM, 30-40% COARSE TO FINE SAND, MOSTLY FINE, BROWNISH GRAY
							TOP OF CLAY AT 33 FT
	35	SS	7	4-6-10 (16 IN.)	16	CL	SILTY CLAY, SLIGHTLY PLASTIC, STIFF TO VERY STIFF, GREENISH GRAY
		US	8		-	CL	CLAY, MODERATELY PLASTIC, GREENISH GRAY
	40	SS	9	10-9-10 (18 IN.)	19	CL	CLAY, MODERATELY PLASTIC, VERY STIFF, GREENISH GRAY, ONE 0.7 IN. GRAVEL PARTICLE
		SS	10	8-8-8 (18 IN.)	16	CL-CH	CLAY, MODERATELY TO HIGHLY PLASTIC, STIFF TO VERY STIFF, GREENISH GRAY
	45	US	11		-	CL-CH	CLAY, SAME AS ABOVE
		SS	12	4-4-5 (18 IN.)	9	CL-CH	CLAY, MODERATELY TO HIGHLY PLASTIC, FIRM TO STIFF, GREENISH GRAY
	50	SS	13	5-4-5 (18 IN.)	9	CL-CH	CLAY, SIMILAR TO ABOVE EXCEPT, ONE 0.4 IN. GRAVEL
		SS	14	5-4-5 (18 IN.)	9	CL-CH	CLAY, SIMILAR TO ABOVE EXCEPT NO GRAVEL
	55	SS	15	1-2-3 (18 IN.)	5	CL-CH	CLAY, SIMILAR TO ABOVE, EXCEPT SOFT TO FIRM
		SS	16	1-2-3 (18 IN.)	5	CL-CH	CLAY, SAME AS ABOVE
	60	SS	17	WOH 4-4 (18 IN.)	8	CL-CH	CLAY, SIMILAR TO ABOVE EXCEPT, FIRM TO STIFF.
		SS	18	WOR 2-3 (18 IN.)	5	CL-CH	CLAY, SIMILAR TO ABOVE EXCEPT, SOFT TO FIRM
	65						
	70	SS	19	6-5-6 (18 IN.)	11	CL-CH	CLAY, SAME AS ABOVE NOTE: RODS DROPPED WHILE LOWERING. SPLIT SPOON SAMPLER, N VALUE LIKELY AFFECTED
	75	SS	20	WOR WOR 2-6 (24 IN.)	2	CL-CH	CLAY, SIMILAR TO ABOVE EXCEPT, VERY SOFT TO SOFT.
	80						BOTTOM OF CLAY AT 81 FT
		SS	21	WOR 2-19-33 (24 IN.)	21	CL-CH, SC	CLAY, SAME AS ABOVE (TOP 16 IN.) CLAYEY SAND, WIDELY GRADED, 20-30% GRAVEL TO 1 IN. COARSE TO FINE, MOSTLY FINE SAND, 20-30% SLIGHTLY PLASTIC FINES, GREENISH GRAY (BOTTOM 8 IN.)
	85	SS	22	[illegible]	[illegible]	SM	CLAYEY SAND, WIDELY GRADED, 20-30% GRAVEL UP TO 1.5 IN., COARSE TO FINE, MOSTLY FINE SAN[illegible] NOTE: A PIECE OF GRAVEL LIMITED THE RECOVERY TO 2 IN. TOTAL RECOVERY.
	90						

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.	STONE & WEBSTER ENG. CORP. SKETCH No.	APPROVED	DATE	BORING NO.	SHEET
				SF-1	2 OF 3

BORING NO.	SF-1
SHEET	3 OF 3

SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 16499.27

ELEVATION (FEET) (1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	23	27-43-65-99 (8 IN.)	108	SM	CLAYEY SAND, WIDELY GRADED, 20-30% GRAVEL UP TO 2 IN., COARSE TO FINE, MOSTLY FINE SAND, 20-30% SLIGHTLY PLASTIC FINES, GREENISH GRAY
							END OF BORING AT 92 FT
	95						

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.	STONE & WEBSTER ENG. CORP. SKETCH No.	APPROVED	DATE	BORING NO. SF-1	SHEET 3 OF 3

SITE: DEER ISLAND SECONDARY TREATMENT FACILITY
J.O. NO. 16499.27
BORING NO. SF-2
SHEET 1 OF 2

COORDINATES: N493,540 E745,260
GROUND ELEV. (1): APPROX. 125 FT
INCLINATION: VERTICAL
BEARING: -
INSPECTOR: HASAN ABEDI
DATE: START / FINISH: 8/20/87 / 8/21/87
CONTRACTOR / DRILLER: EMS/CHARLES REIL
STATIC GROUNDWATER DEPTH / DATE: (FT) /
DRILL RIG TYPE: MOBILE B-57
DEPTH TO BEDROCK: (FT)
TOTAL DEPTH DRILLED: 62 (FT)

METHODS:

DRILLING SOIL: ROLLER BIT TO 62 FT., CASING DRIVEN TO 20 FT., WATER

SAMPLING SOIL: SPLIT SPOON AT 5 FT INTERVALS TO 62 FT, SHELBY TUBE SAMPLE AT 35 FT

DRILLING ROCK: NONE

SPECIAL TESTING OR INSTRUMENTATION:

COMMENTS:

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
	0						FILL: SANDY GRAVEL, 20-40% BOLDERS AND COBBLES TO 20 IN. MAXIMUM, 20-40% SAND, 5-10% FINES, LIGHT BROWN
	2.5						
	5						FILL: SANDY SILT, SLIGHTLY PLASTIC, 10-20% GRAVEL UP TO 3 IN., SOME ROOTS, 10-20% COARSE TO FINE SAND, BROWNISH GRAY
		SS	1	7-7-8 (10 IN.)	15		FILL: SANDY SILT, SLIGHTLY PLASTIC, 10-20% MEDIUM TO FINE SAND, STIFF, BROWNISH GRAY
	10	SS	2	4-2-2	4		NO RECOVERY
	15	SS	3	15-12-10-14 (6 IN.)	22		FILL: SILTY SAND, WIDELY GRADED, 10-20% GRAVEL UP TO 1 IN. 10-20% SLIGHTLY PLASTIC, FINES, BROWNISH GRAY
	20	SS	4	10-10-13 (5 IN.)	23	CL	CLAY, MODERATELY PLASTIC, 5-10% FINE SAND, VERY STIFF, BROWN
	25	SS	5	6-9-10 (? IN.)	19	CL	CLAY, MODERATELY PLASTIC, VERY STIFF, GREENISH GRAY, 0.5 IN. GRAVEL PARTICLE
	30						

LEGEND / NOTES

1. DATUM IS MDC SEWER DATUM (MDC = USGS + 105.62 FT)
2. ▽ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". * INDICATES USE OF 300lb. HAMMER ( ) INCHES OF SAMPLE RECOVERY
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. SS = SPLIT SPOON
8. US = UNDISTURBED SAMPLE

BORING LOG

DEER ISLAND SECONDARY TREATMENT FACILITY

MWRA

STONE & WEBSTER ENG. CORP
SKETCH No.

APPROVED	DATE	BORING NO.	SHEET
U.E. Killeen		SF-2	1 OF 2

BORING NO. SF-2

SHEET 2 OF 2

SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 16499.27

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	6	4-8-9-11 (15 IN.)	17	CL	CLAY, MODERATELY PLASTIC, VERY STIFF, GREENISH GRAY, 0.3 IN. GRAVEL PARTICLE
	35	US	7			CL-CH	CLAY, MODERATELY TO HIGHLY PLASTIC, GREENISH GRAY.
	37	SS	8	3-6-6 (17 IN.)	12	CL-CH	CLAY, SIMILAR TO ABOVE EXCEPT, STIFF
	40						
							ENCOUNTERED PIECES OF GRAVEL AT 45 FT.
							CLAY, MODERATELY TO HIGHLY PLASTIC. GREENISH GRAY, SEVERAL GRAVEL PARTICLES UP TO 1 IN. MAXIMUM (TOP 3 IN.)
	45	SS	9	9-4-4-5	8	CL-CH	CLAY, MODERATELY TO HIGHLY PLASTIC, MEDIUM GREENISH GRAY.
							BOTTOM OF CLAY AT 48 FT.
	50	SS	10	11-15-23-36	38		NO RECOVERY
		SS	11	11-10-9-16	19		NO RECOVERY
	55	SS	12	6-6-10-26-28 (6 IN.)	36	SC-SM	CLAYEY SAND, WIDELY GRADED, 20-30% GRAVEL TO 1 IN. MAXIMUM, COARSE TO FINE SAND, 20-30% SLIGHTLY PLASTIC FINES, GREEN GRAY
	60	SS	13	32-59-72-30 (13 IN.)	131	SC-SM	CLAYEY SAND, WIDELY GRADED, 10-30% GRAVEL UP TO 1 IN., COARSE TO FINE SAND, 20-30% SLIGHTLY PLASTIC FINES, GREENISH GRAY.
							END OF BORING AT 62 FT

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.

STONE & WEBSTER ENG. CORP. SKETCH No.

APPROVED	DATE	BORING NO.	SHEET
[illegible signature]		SF-2	2 OF 2

SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 16499.27

BORING NO. SF-3

SHEET 1 OF 2

COORDINATES N493,250 E746,550 GROUND ELEV. (1) 139 FT

INCLINATION VERTICAL BEARING ______ INSPECTOR HASAN ABEDI

DATE : START / FINISH 8/24/87 / 8/25/87 CONTRACTOR / DRILLER EMS/CHARLES REIL

STATIC GROUNDWATER DEPTH / DATE ______ (FT) / ______ DRILL RIG TYPE MOBILE B-57

DEPTH TO BEDROCK ______ (FT) TOTAL DEPTH DRILLED 86.5 (FT)

METHODS :

DRILLING SOIL ROLLER BIT TO 86 FT., WATER, CASING DRIVEN TO 40 FT

SAMPLING SOIL SPLIT SPOON AT 5 FT INTERVALS. SHELBY TUBE AT 65 FT DEPTH

DRILLING ROCK ______

SPECIAL TESTING OR INSTRUMENTATION ______

COMMENTS ______

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	1	11-85 (9 IN.)			FILL: SANDY SILT, SLIGHTLY PLASTIC, 10-20% GRAVEL TO 2.5 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, LIGHT BROWN, SOME ROOTS. NOTE: REFUSAL @ DEPTH OF 1 FT
	5	SS	2	16-22-31 (10 IN.)	53		FILL: SANDY SILT, SLIGHTLY PLASTIC, 5-10% GRAVEL TO 1.5 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, BROWNISH GRAY
	10	SS	3	8-13-16-15 (8 IN.)	29		FILL: SANDY SILT, SLIGHTLY PLASTIC, WIDELY GRADED, 5-10% GRAVEL TO 0.5 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, BROWNISH GRAY
	15	SS	4	11-6-6-13 (10 IN.)	12		FILL: SANDY CLAY, SLIGHTLY TO MODERATELY PLASTIC, 10-20% GRAVEL TO 0.5 IN. MAXIMUM, 20-30% COARSE TO FINE SAND, MOSTLY FINE, STIFF, GREENISH GRAY
	20	SS	5	7-5-5-7	10		NO RECOVERY (2 ATTEMPTS)
							— BOTTOM OF FILL AT 24 FT —
	25	SS	6	42-36-43 (3 IN.)	79	CL	SANDY CLAY, SLIGHTLY TO MODERATELY PLASTIC, 10-20% GRAVEL TO 0.5 IN. MAXIMUM 15-25% COARSE TO FINE SAND, HARD, BROWNISH GRAY INTERMIXED WITH GREENISH GRAY
	30						

LEGEND / NOTES

1. DATUM IS MDC SEWER DATUM (MDC = USGS + 105.62 FT)
2. ▽ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". ✱ INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. SS = SPLIT SPOON
8. US = UNDISTURBED SAMPLE

BORING LOG

DEER ISLAND SECONDARY TREATMENT FACILITY

MWRA

STONE & WEBSTER ENG. CORP
SKETCH No.

APPROVED	DATE	BORING NO.	SHEET
		SF-3	1 OF 2

BORING NO.	SF-3
SHEET 2 OF	2

SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 16499.27

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	7	19-45-70 (16 IN.)	115	CL	SANDY CLAY, SIMILAR TO ABOVE EXCEPT GRAVEL TO 0.3 IN.
	35	SS	8	22-20-22-14 (12 IN.)	42	SM	SILTY SAND, WIDELY GRADED, 5-10% GRAVEL TO 0.5 IN. MAXIMUM, 5-10% FINES, BROWNISH GRAY (TOP 7 IN.)
							TOP OF CLAY @ 37.5 FT
						CL-ML	SANDY CLAY, slightly plastic, 15-30% COARSE TO FINE SAND, GREENISH GRAY (BOTTOM 5 IN.)
	40	SS	9	5-10-11 (8 IN.)	21	CL	CLAY, MODERATELY PLASTIC, 5-10% MEDIUM TO FINE SAND, VERY STIFF, GREENISH GRAY. NOTE: A PIECE OF GRAVEL (1.5 IN.) BLOCKED THE SPOON, LIMITED THE RECOVERY TO 8 IN.
	45	SS	10	1-2-2-3 (18 IN.)	4	CL	CLAY, MODERATELY PLASTIC, SOFT, GREENISH GRAY
	50	SS	11	1-3-3-4 (20 IN.)	6	CL-CH	CLAY, MODERATELY TO HIGHLY PLASTIC, FIRM,GREENISH GRAY
	55	SS	12	2-2-3-3 (16 IN.)	5	CL-	CLAY, SAME AS ABOVE
	60	SS	13	WOH 3-4-4 (24 IN.)	7	CL-CH	CLAY, SAME AS ABOVE
	65	US	14			CL-CH	CLAY, SAME AS ABOVE
		SS	15	3-[illegible] ([illegible] IN.)	6	CL-	CLAY, SAME AS ABOVE
	70						
	75	SS	16	WOH 4-3-4-6 (24 IN.)	7	CL	CLAY, MODERATELY PLASTIC, 5-10% FINE SAND, GREENISH GRAY, ONE PIECE OF 1 IN. GRAVEL
	80	SS	17	4-4-3 (18 IN.)	7	CL	SANDY CLAY, SLIGHTLY TO MODERATELY PLASTIC, 10-15% GRAVEL UP TO 1 IN. MAXIMUM, 10-30% COARSE TO FINE SAND, GREENISH GRAY
	82.5						BOTTOM OF CLAY AT 82.5 FT
							NOTE: ROLLER BITTED THROUGH 3.5 FT OF ROCK 82.5 FT-86 FT
	85		[illegible]	[illegible]			[illegible]
							NOTE: LOST WATER IN THE HOLE AT 86.5 FT (MAY BE BEDROCK SURFACE)
	90						END OF BORING @ 86.5 FT

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.	STONE & WEBSTER ENG. CORP. SKETCH No.	APPROVED [signature]	DATE	BORING NO. SF-3	SHEET 2 OF 2

SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 16499.27

BORING NO. SF-4

SHEET 1 OF 2

COORDINATES N493,430 E746,320 GROUND ELEV. (1) APPROX +136 FT

INCLINATION VERTICAL BEARING ______ INSPECTOR HASAN ABEDI

DATE : START / FINISH 8/25/87 / 8/26/87 CONTRACTOR / DRILLER EMS/CHARLES REIL

STATIC GROUNDWATER DEPTH / DATE ____ (FT) / ____ DRILL RIG TYPE MOBILE B-57

DEPTH TO BEDROCK ____ (FT) TOTAL DEPTH DRILLED 67 (FT)

METHODS :

DRILLING SOIL ROLLER BIT TO 67 FT WITH WATER, CASING DRIVEN TO 30 FT.

SAMPLING SOIL SPLIT SPOON AT 5 FT INTERVALS

DRILLING ROCK ______

SPECIAL TESTING OR INSTRUMENTATION ______

COMMENTS ______

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
	0						FILL: SANDY GRAVEL, BOULDERS AND COBBLES TO 24 IN. MAXIMUM, 20-40% SAND, 10-20% FINES, LIGHT BROWN
	5						FILL: SANDY SILT, SLIGHTLY PLASTIC, 10-30% GRAVEL TO 1.5 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, MOIST, BROWNISH GRAY
	10	SS	1	3-3-2-10 (12 IN.)	5		FILL: SANDY SILT, SLIGHTLY PLASTIC, 10-20% GRAVEL TO 0.5 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, FIRM, BROWNISH GRAY
	15	SS	2	17-13-13 (8 IN.)	26		FILL: SANDY SILT, SLIGHTLY PLASTIC, 5-10% GRAVEL TO 1 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, VERY STIFF, BROWNISH GRAY
	20	SS	3	12-16-22-14 (11 IN.)	38		FILL: SANDY SILT, 5-10% GRAVEL TO 0.6 IN. MAXIMUM, 10-15% COARSE TO FINE SAND, HARD, GREENISH GRAY
	25	SS	4	22-7-6-7 (6 IN.)	13		FILL: SANDY SILT, 5-10% GRAVEL TO 0.5 IN. MAXIMUM, 15-20% COARSE TO FINE SAND, STIFF, BROWNISH GRAY
							BOTTOM OF FILL @ 28.5 FT
	30						TOPSOIL OR PEAT AT 28.5 FT

LEGEND / NOTES

1. DATUM IS (MDC SEWER DATUM (MDC - USGS + 105.62 FT)
2. ▽ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". * INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. SS = SPLIT SPOON

BORING LOG

DEER ISLAND SECONDARY TREATMENT FACILITY

MWRA

STONE & WEBSTER ENG. CORP
SKETCH No.

APPROVED	DATE	BORING NO.	SHEET
C.E.F. Kiesler		SF-4	1 OF 2

BORING NO. SF-4

SHEET 2 OF 2

SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 16499.27

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	5	5-12-14 (10 IN.)	26	CL	CLAY, SLIGHTLY TO MODERATELY PLASTIC, 1-5% COARSE TO FINE SAND, VERY STIFF, GREENISH GRAY
	35	SS	6	7-9-13-18 17 IN.)	22	CL	CLAY, MODERATELY PLASTIC, VERY STIFF, GREENISH GRAY. 1-5% COARSE SAND IN TOP 6 IN.
	40	SS	7	4-7-9-10 (12 IN.)	16	CL	CLAY, MODERATELY PLASTIC, VERY STIFF, GREENISH GRAY, SEVERAL GRAVEL PARTICLES TO 1 IN. MAXIMUM
	45	SS	8	4-6-7-8 (10 IN.)	13	CL-CH	CLAY, MODERATELY TO HIGHLY PLASTIC, FIRM TO STIFF, GREENISH GRAY
	50	SS	9	3-5-6-7 17 IN.)	11	CL-CH	CLAY, SAME AS ABOVE
	55	SS	10	10-12-12 (16 IN.)	24	CL CL	CLAY, MODERATELY PLASTIC, 5-15% COARSE SAND, GREENISH GRAY (TOP 8 IN.) SANDY CLAY, SLIGHTLY PLASTIC, 15-30% SLIGHTLY PLASTIC, COARSE TO FINE SAND, STIFF, GREENISH GRAY
	57.5						— — — BOTTOM OF CLAY @ 57.5 FT — — —
	60	SS	11	17-29-30-34 (4 IN.)	59	CL	SANDY CLAY, SIMILAR TO ABOVE EXCEPT 15-25% GRAVEL TO 1.0 IN. MAXIMUM
	65	SS	12	19-34-34-57 (8 IN.)	68	CL	SANDY CLAY, SAME AS ABOVE
							END OF BORING AT 67 FT

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1

STONE & WEBSTER ENG. CORP. SKETCH No.

APPROVED	DATE	BORING NO.	SHEET
W K Lee		SF-4	2 OF 2

BORING NO.	SF-5
SHEET	1 OF 2

SITE: DEER ISLAND SECONDARY TREATMENT FACILITY — J.O. NO.: 16499.27

COORDINATES: N493,720 E746,140 — GROUND ELEV. (1): APPROX +121 FT

INCLINATION: VERTICAL — BEARING: — INSPECTOR: HASAN ABEDI

DATE: START / FINISH: 8/27/87 / 8/27/87 — CONTRACTOR / DRILLER: EMS/CHARLES REIL

STATIC GROUNDWATER DEPTH / DATE: (FT) / — DRILL RIG TYPE: MOBILE B-57

DEPTH TO BEDROCK: (FT) — TOTAL DEPTH DRILLED: 32 (FT)

METHODS:

DRILLING SOIL: ROLLER BIT TO 32 FT WITH WATER. CASING DRIVEN TO 10 FT

SAMPLING SOIL: SPLIT SPOON AT 5 FT INTERVALS

DRILLING ROCK:

SPECIAL TESTING OR INSTRUMENTATION:

COMMENTS:

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
	0						FILL: SANDY SILT, WIDELY GRADED, 5-15% GRAVEL TO 2 IN. MAXIMUM, 10-20% COARSE TO FINE SAND, LIGHT BROWN, DRY
	5	SS	1	20-13-14-19 (17 IN.)	27	ML	SANDY SILT, SLIGHTLY PLASTIC, 1-5% GRAVEL TO 1 IN. MAXIMUM, 5-15% MEDIUM TO FINE SAND, LAYERS OF BROWNISH GRAY OVER GREENISH GRAY (GREENISH GRAY LAYER DOES NOT CONTAIN ANY GRAVEL), MOIST.
						SM	SILTY SAND, WIDELY GRADED, 5-15% FINES BROWNISH GRAY, (BOTTOM 3 IN.)
							TOP OF CLAY @ 8 FT
	10	SS	2	6-11-13-20 (10 IN.)	24	CL	CLAY, MODERATELY PLASTIC, 2-5% SAND, VERY STIFF, GREENISH GRAY, SEVERAL PIECES OF GRAVEL TO 1.2 IN. MAXIMUM.
	15	SS	3	4-6-8-9 (17 IN.)	14	CL	CLAY, SIMILAR TO ABOVE EXCEPT STIFF, SAND SEAM @ 6 IN. FROM TOP
							BOTTOM OF CLAY @ 18 FT
	20	SS	4	23-24-24 (2 IN.)	48	CL	SANDY CLAY, SLIGHTLY PLASTIC, 15-25% COARSE TO FINE SAND, HARD GREENISH GRAY, ONE PIECE OF 1 IN. GRAVEL
	25	SS	5	24-47-44 (10 IN.)	91	CL	SANDY CLAY, SLIGHTLY PLASTIC, 20-30% GRAVEL TO 1 IN. MAXIMUM, 20-30% COARSE TO FINE SAND, HARD, GREENISH GRAY (TILL)
	30						

LEGEND / NOTES

1. DATUM IS MDC SEWER DATUM (MDC = USGS + 105.62 FT)
2. ▽ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". * INDICATES USE OF 300lb HAMMER. ( ) INCHES OF SAMPLE RECOVERY
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. SS = SPLIT SPOON

BORING LOG

DEER ISLAND SECONDARY TREATMENT FACILITY

MWRA

STONE & WEBSTER ENG. CORP
SKETCH No.

APPROVED	DATE	BORING NO.	SHEET
		SF-5	1 OF 2

BORING NO. SF-5

SHEET 2 OF 2

SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 16499.27

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	6	21-24-34- (13 IN.)	63	CL	SANDY CLAY, SLIGHTLY PLASTIC, 20-30% GRAVEL TO 1.5 IN. MAXIMUM WIDELY GRADED, 20-30% COARSE TO FINE SAND, MOSTLY FINE, HARD GREENISH GRAY.
							END OF BORING AT 32 FT
	35						

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.

STONE & WEBSTER ENG. CORP. SKETCH No.

APPROVED	DATE	BORING NO.	SHEET
WEK 12/21		SF-5	2 OF 2

SITE: DEER ISLAND SECONDARY TREATMENT FACILITY — J.O. NO. 16499.27

BORING NO. LF-1 — SHEET 1 OF 2

COORDINATES: N490,570 E747,250 — GROUND ELEV. (1) APPROX. 117 FT

INCLINATION: VERTICAL — BEARING: — INSPECTOR: HASAN ABEDI

DATE: START / FINISH: 8/28/87 / 8/31/87 — CONTRACTOR / DRILLER: EMS/CHARLES REIL

STATIC GROUNDWATER DEPTH / DATE: (FT) / — DRILL RIG TYPE: MOBILE B-57

DEPTH TO BEDROCK: (FT) — TOTAL DEPTH DRILLED: 56 (FT)

METHODS:

DRILLING SOIL: ROLLER BIT WITH WATER. CASING DRIVEN TO 50 FT

SAMPLING SOIL: SPLIT SPOON AT 5 FT INTERVALS

DRILLING ROCK:

SPECIAL TESTING OR INSTRUMENTATION:

COMMENTS:

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
	0						FILL: GRAVELLY SAND, WIDELY GRADED, 10-20% GRAVEL TO 1 IN. MAXIMUM, 5-15% FINES, DRY, LOOSE MATERIAL, BROWNISH GRAY, 5-10% COBBLES.
	5						
	10	SS	1	15-8-7-3 (9 IN.)	15		FILL: GRAVELLY SAND, WIDELY GRADED, 10-20% GRAVEL TO 1 IN. MAXIMUM, 5-10% FINES, LOOSE, BROWNISH GRAY. BOTTOM 2 IN. SANDY CLAY SLIGHTLY TO MOD PLASTIC, 20-30% COARSE TO FINE SAND, STIFF GREENISH GRAY. BOTTOM OF FILL AT 13 FT
	15	SS	2	18-26-33 (17 IN.)	59	CL	SANDY CLAY, SLIGHTLY TO MODERATELY PLASTIC, 20-30% COARSE TO FINE SAND, MOSTLY FINE, HARD BROWNISH GRAY.
	20	SS	3	15-23-30 (17 IN.)	53	CL	SANDY CLAY, SIMILAR TO ABOVE EXCEPT ONE 0.75 IN. GRAVEL PARTICLE.
	25	SS	4	22-26-37 (13 IN.)	63	ML	SANDY CLAY, SLIGHTLY TO MODERATELY PLASTIC, 10-20% GRAVEL TO 1 IN. MACIMUM, 20-30% MEDIUM to FINE SAND, GREENISH GRAY.
	30						

LEGEND / NOTES

1. DATUM IS MDC SEWER DATUM (MDC = USGS + 105.62 FT)
2. ▽ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". * INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT.
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. SS = SPLIT SPOON

BORING LOG

DEER ISLAND SECONDARY TREATMENT FACILITY

MWRA

STONE & WEBSTER ENG. CORP
SKETCH No.

APPROVED	DATE	BORING NO.	SHEET
C.E. Kilhes		LF-1	1 OF 2

BORING NO. LF-1

SHEET 2 OF 2

SITE DEER ISLAND SECONDARY TREATMENT FACILITY J.O. NO. 16499.27

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	5	31-56-65	121		NOTE: NO RECOVERY - 2 ATTEMPTS
	35	SS	6	15-19-25 -38 (13 IN.)	44	CL	SANDY CLAY, SIMILAR TO ABOVE EXCEPT GRAVEL TO 0.8 IN. MAXIMUM.
	40	SS	7	15-20-24 -45 (11 IN.)	44	CL	SANDY CLAY, SAME AS ABOVE
	45	SS	8	116/5 IN. 45-20-23* (5 IN.)		CL	SANDY CLAY, SLIGHTLY PLASTIC, 20-30% GRAVEL TO 1.5 IN. MAXIMUM, 10-30% COARSE TO FINE SAND, GREENISH GRAY
	50	SS	9	14-25-55 -[illegible] ([illegible] IN.)	80	CL	SANDY CLAY, 5-15% GRAVEL TO 1.5 IN. MAXIMUM, SLIGHTLY PLASTIC, 20-40% COARSE TO FINE SAND, GREENISH GRAY NOTE: A PIECE OF WEATHERED ROCK BLOCKED THE SPOON, LIMITED THE RECOVERY TO 5 IN.
	55	SS	10	40-[illegible]-20* ([illegible] IN.)			SANDY CLAY, SAME AS ABOVE
							END OF BORING AT 56 FT
	60						

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1

STONE & WEBSTER ENG. CORP. SKETCH No.

APPROVED	DATE	BORING NO.	SHEET
		LF-1	2 OF 2

SITE NUT ISLAND, MASSACHUSETTS J.O. NO. 16499.27

BORING NO. PSN-1
SHEET 1 OF 3

COORDINATES N466,685 E747,410 GROUND ELEV. (1) APPROX. 131 FT

INCLINATION VERTICAL BEARING ______ INSPECTOR T. L. ANNARATONE

DATE : START / FINISH 4-16-87 / 4-17-87 CONTRACTOR / DRILLER NEW ENGLAND BORING/RAMSDELL

STATIC GROUNDWATER DEPTH / DATE 13 (FT) / 4-17-87 DRILL RIG TYPE MOBILE DRILL - B-61

DEPTH TO BEDROCK 95.5 (FT) TOTAL DEPTH DRILLED 105.5 (FT)

METHODS :

DRILLING SOIL TRICONE ROLLER BIT WITH WATER

SAMPLING SOIL SPLIT SPOON

DRILLING ROCK NWD4 CORE BARREL

SPECIAL TESTING OR INSTRUMENTATION ______

COMMENTS ______

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
	0						NO RECOVERY AUGERED TOP 10 FT THROUGH 4 IN. THICK ASPHALT PAVEMENT, FILL AND SANDY CLAY
	5						
	10	SS	1	9-8-12-13 (24")	20	CL	SANDY CLAY, SLIGHTLY TO MODERATELY PLASTIC, 25-35% COARSE TO FINE SAND, SOME GRAVEL TO 0.5 IN. MAXIMUM, LIGHT YELLOW BROWN
	15	SS	2	14-18-17 (12")	35	SC	SANDY CLAY, SLIGHTLY TO MODERATELY PLASTIC, 30-40% COARSE TO FINE SAND, SOME GRAVEL TO 0.25 IN. MAXIMUM, LIGHT BROWN
	20	SS	3	[illegible] (12")	41	[illegible]	SANDY CLAY, SLIGHTLY PLASTIC, 20-25% COARSE TO FINE SAND, SOME GRAVEL TO 0.25 IN. MAXIMUM BROWN
	25						
	30						

LEGEND / NOTES

1. DATUM IS PLANT DATUM, 100 FT ABOVE MEAN LOW TIDE
2. ▼ GROUND WATER LEVEL
3. BLOWS REQUIRED TO DRIVE 2" O.D. SAMPLE SPOON 6" OR DISTANCE SHOWN USING 140lb. HAMMER FALLING 30". ✱ INDICATES USE OF 300lb. HAMMER. ( ) INCHES OF SAMPLE RECOVERY
4. % ROCK CORE RECOVERY/ ROCK QUALITY DESIGNATION.
5. STD. PENETRATION RESISTANCE BLOWS/FT.
6. UNIFIED SOIL CLASSIFICATION SYSTEM.
7. SS - SPLIT SPOON

BORING LOG

DEER ISLAND SECONDARY TREATMENT FACILITY

MWRA

STONE & WEBSTER ENG. CORP
SKETCH No.

APPROVED	DATE	BORING NO.	SHEET
WEK[illegible]		PSN-1	1 OF 3

SITE NUT ISLAND, MASSACHUSETTS J.O. NO. 16499.27

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	4	37-32-26 (14")	58	SC	CLAYEY SAND, WIDELY GRADED, 10-20% GRAVEL TO 0.4 IN. MAXIMUM, COARSE TO FINE SAND, 30-40% SLIGHTLY PLASTIC FINES, GREEN BROWN (TILL)
	35						
	40	SS	5	32-23-38 (4")	61	SC	CLAYEY SAND, WIDELY GRADED, 10-20% GRAVEL TO 0.4 IN. MAXIMUM, COARSE TO FINE SAND, 30-40% SLIGHTLY PLASTIC FINES, GREEN BROWN (TILL)
	45						
	50	SS	6	18-15-15 (5")	30	ML-CL	SILTY CLAY, SLIGHTLY TO MODERATELY PLASTIC, 10-15% COARSE TO FINE SAND, GRAY (TILL)
	55						(LAYER OF COBBLES AT 55 FT)
	60	SS	7	20-38-29 (9")	67	CL	SANDY CLAY, MODERATELY PLASTIC, 10-15% GRAVEL TO 0.4 IN. MAXIMUM, 30-35% COARSE TO FINE, MOSTLY FINE, SAND, GREEN GRAY, (TILL)
	65						
	70	SS	8	52-44-62 (14")	106	CL	SANDY CLAY, MODERATELY PLASTIC, 10-15% GRAVEL TO 0.4 IN. MAXIMUM, 30-35% COARSE TO FINE, MOSTLY FINE, SAND, GREEN GRAY, (TILL)
	75						
	80	SS	9	23-30-35 (15")	65	SC	SANDY CLAY, MODERATELY PLASTIC, STIFF, 10-15% GRAVEL TO 0.4 IN. MAXIMUM, 25-30% COARSE TO FINE SAND, GREEN GRAY (TILL)
	85						
	90						

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1

STONE & WEBSTER ENG. CORP. SKETCH No.

APPROVED	DATE	BORING NO	SHEET
[illegible]		PSN-1	2 OF 3

BORING NO. PSN-1
SHEET 3 OF 3

SITE NUT ISLAND, MASSACHUSETTS J.O. NO. 16499.27

ELEVATION (FEET)(1&2)	DEPTH (FEET)	SAMPLE TYPE (7)	SAMPLE NUMBER	BLOWS (3) OR REC/RQD (4)	SPT N VALUE (5)	GROUP SYMBOL (6)	SAMPLE DESCRIPTION
		SS	10	26-38 100/5" (14")	138 11"		SANDY CLAY, MODERATELY PLASTIC, STIFF, 10-15% GRAVEL TO 0.4 IN. MAXIMUM, 25-30% COARSE TO FINE SAND, GREEN GRAY (TILL)
							TOP OF ROCK AT 95.5 FT
	95	NX	1	56/7			DK GRAY TO BLACK ARGILLITE V. THIN LAM. @ 45°± (VARIABLE WHERE BEDDING IS DISTURBED), FRESH, MOD HARD TO HARD, V. FINE GRAINED (CLAY TO SILT SIZE), FREQUENT LIGHT COLORED BANDS (<¼" THICK, FINE GRAINED, CALCAREOUS) NUMEROUS THIN VEINLETS OF CALCITE AND OCCASIONAL QUARTZ, JOINTING CLOSELY SPACED.
							95.6-97.6 BEDDING CONTORTED, FREQUENT MINOR OFFSETS (<1/2") ALONG HEALED MICRO SHEARS @ 45°± (COUNTER TO BEDDING)
	100	NX	2	100/46			95.8 JT., 15°, QTZ FILLED; CROSS JT., 45°, SMOOTH, SL. FeO STAIN.
							96.1 JT, 15° CHLORITE COATING
	105						96.2 JT, SUBHOR., QTZ AND CALC FILLED
							96.6 QTZ VEINLET, 10°-15°, 1/8 IN. THICK
							96.8-97.0 BROKEN, HIGHLY FRAGMENTED CORE
							97.0 FRACTURE, 45°, VUGGY, CHLORITE
							97.3 JT., SUBHOR., QTZ W/TR PYRITE
							97.4 JT., 45° SMOOTH, SL. CALCITE; JT, SUBVERT., SL. CALC.
							97.7-100.4 BROKEN, FRAGMENTED CORE
							100.5-102.5 CONTORTED BEDDING, SUBVERT. TO VERT.
							100.5-101.3 NUMEROUS SUBPARALLEL CALCITE VEINLETS AT 20°-40°
							101.4-101.5 BROKEN CORE
							101.6 JT, 45°, IRREG., CALC. COAT
							102.5-105.5 BEDDING @ 45°, OCCAS. OFFSET (UP TO 1/2 IN.) ALONG MICROSHEARS.
							102.9 JT., 45°, SL. CHLOR., SMOOTH
							103.1 JT., SUBHOR, CALC. FILLED
							104.0 JT., SUBHOR, CALC. FILLED
							104.7 JT., 12°, CALC. COAT, TR. PYRITE, SLICKS
							105.0-105.5 INCR. FREQ. OF CALC. VEINLETS OFTEN DISCONTINUOUS
							END OF BORING AT 105.5

NOTE: FOR BORING SUMMARY AND LEGEND INFO. SEE SHEET 1.	STONE & WEBSTER ENG. CORP. SKETCH No.	APPROVED	DATE	BORING NO.	SHEET
		E. E. Keller		PSN-1	3 OF 3

Secondary Treatment Facilities Plan

Volume III

Appendix G
Table of Organization and Position

APPENDIX G

PRELIMINARY TABLE OF ORGANIZATION AND POSITION DESCRIPTIONS

This appendix provides additional supporting information, the suggested functional table of organization, and organizational charts and sample position descriptions for the Deer Island wastewater treatment facilities. The information is provided to supplement and support the discussions of Sections 11.5.1, 11.5.2, and 11.5.3 of this plan.

Functional Table of Organization

Three alternative tables of organization were presented to the MWRA staff representatives and the Operations Review Committee (ORC) for consideration as a personnel structure for operation, maintenance and management of the new Deer Island facilities. The organizational structure was selected for the following reasons:

1. Simplicity of management;
2. The "team" concept for accomplishing the work load;
3. Well-divided and realistic spans of control for the management and supervisory teams;
4. Career paths for all employees;
5. Accountability of performance of personnel; and
6. Extensive involvement of the management and supervisory teams, providing strong leadership.

The functional table of organization identifies in the broadest terms what each team, each section, and each function unit is expected to accomplish in order to provide effective operation of the Deer Island treatment facilities. Separate tables of organization were prepared for each of the five sections. These five sections are presented in Figures G-2 through G-5 and are as follows:

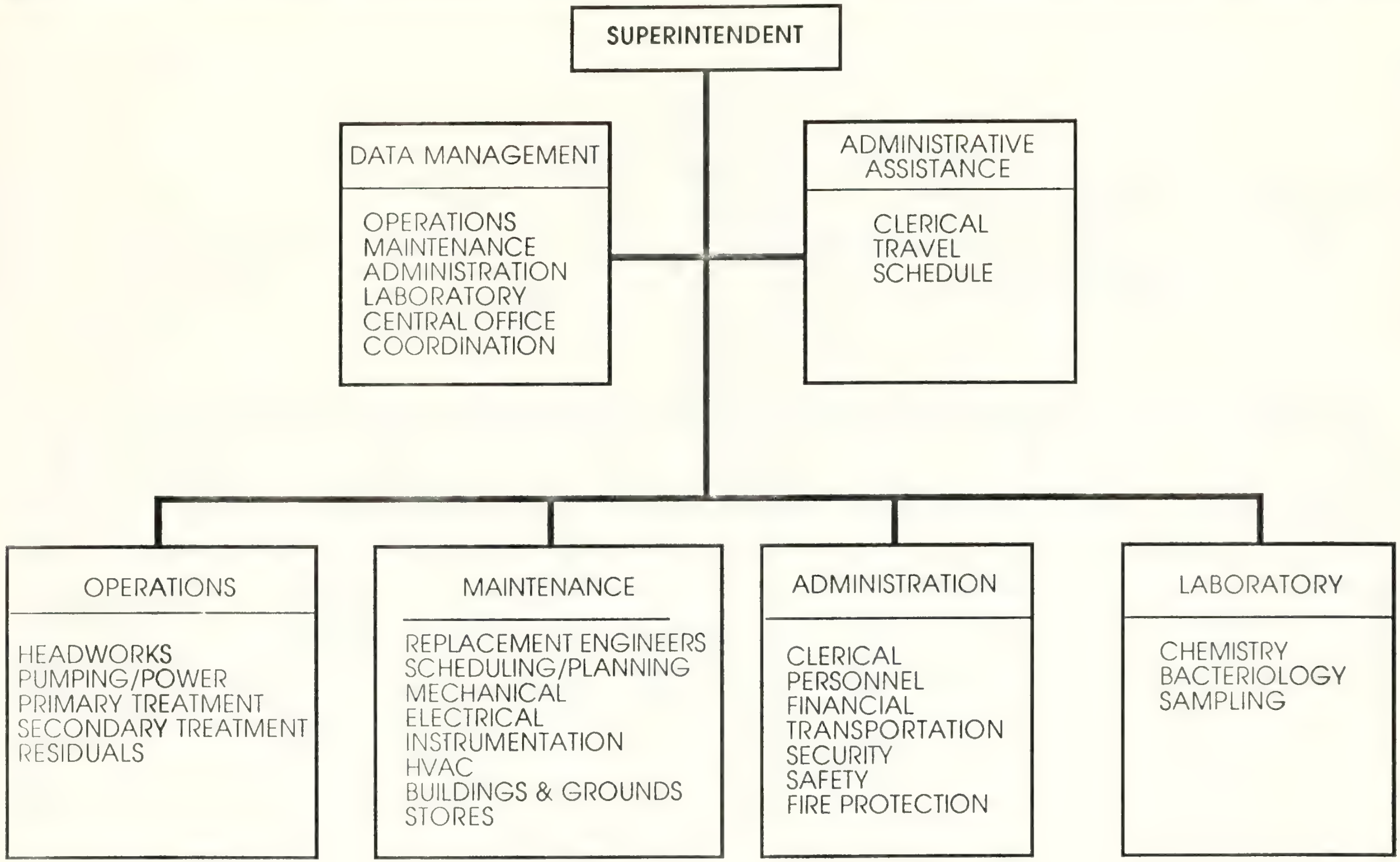
Figure G-1	1...Management Team
Figure G-2	2...Operations Section
Figure G-3	3...Maintenance Section
Figure G-4	4...Administration Section
Figure G-5	5...Laboratory Section

Organizational Charts

Based on the functions that each table of organization outlines, organizational charts were prepared as shown on Figures G-6 to G-14. The organizational charts show the following:

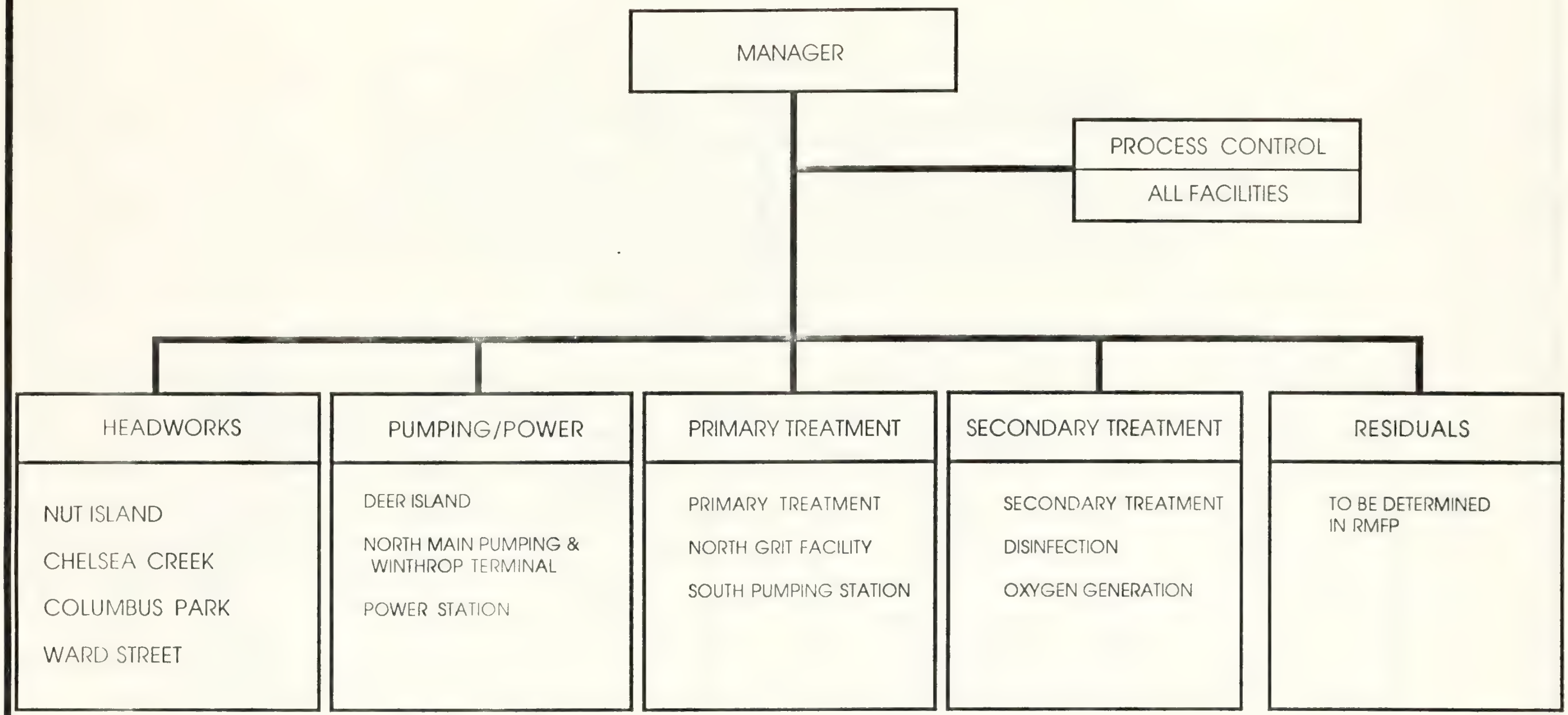
1. Position titles.

2. The number of personnel required in each individual position title and the total (in parentheses) next to the Superintendent and Division Manager positions.



MASSACHUSETTS
WATER RESOURCES
AUTHORITY

FIGURE G-1
DEER ISLAND WASTEWATER TREATMENT COMPLEX
FUNCTIONAL TABLE OF ORGANIZATION -MANAGEMENT TEAM



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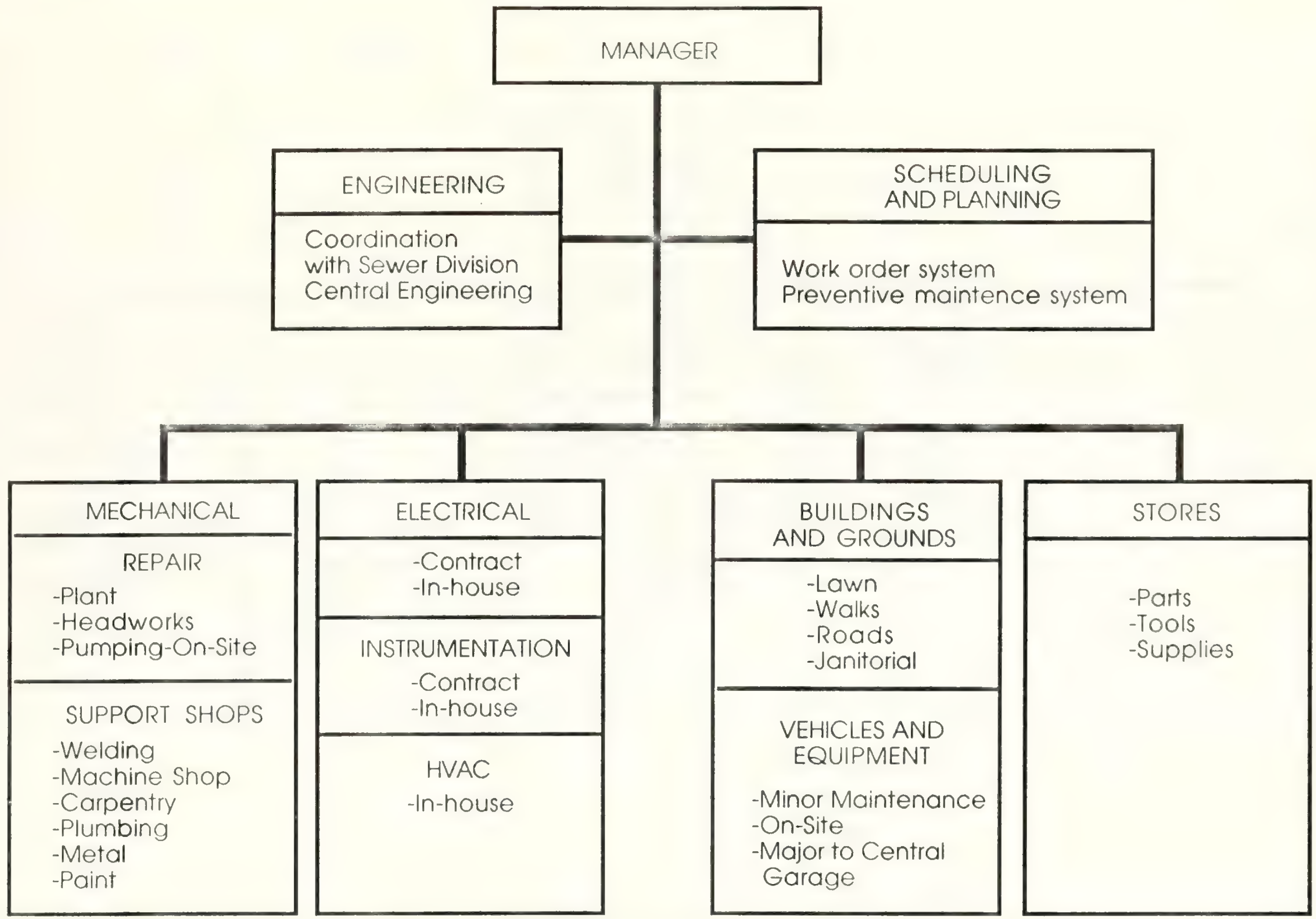
WATER RESOURCES
AUTHORITY

FIGURE G-2
DEER ISLAND WASTEWATER TREATMENT COMPLEX
FUNCTIONAL TABLE OF ORGANIZATION - OPERATIONS



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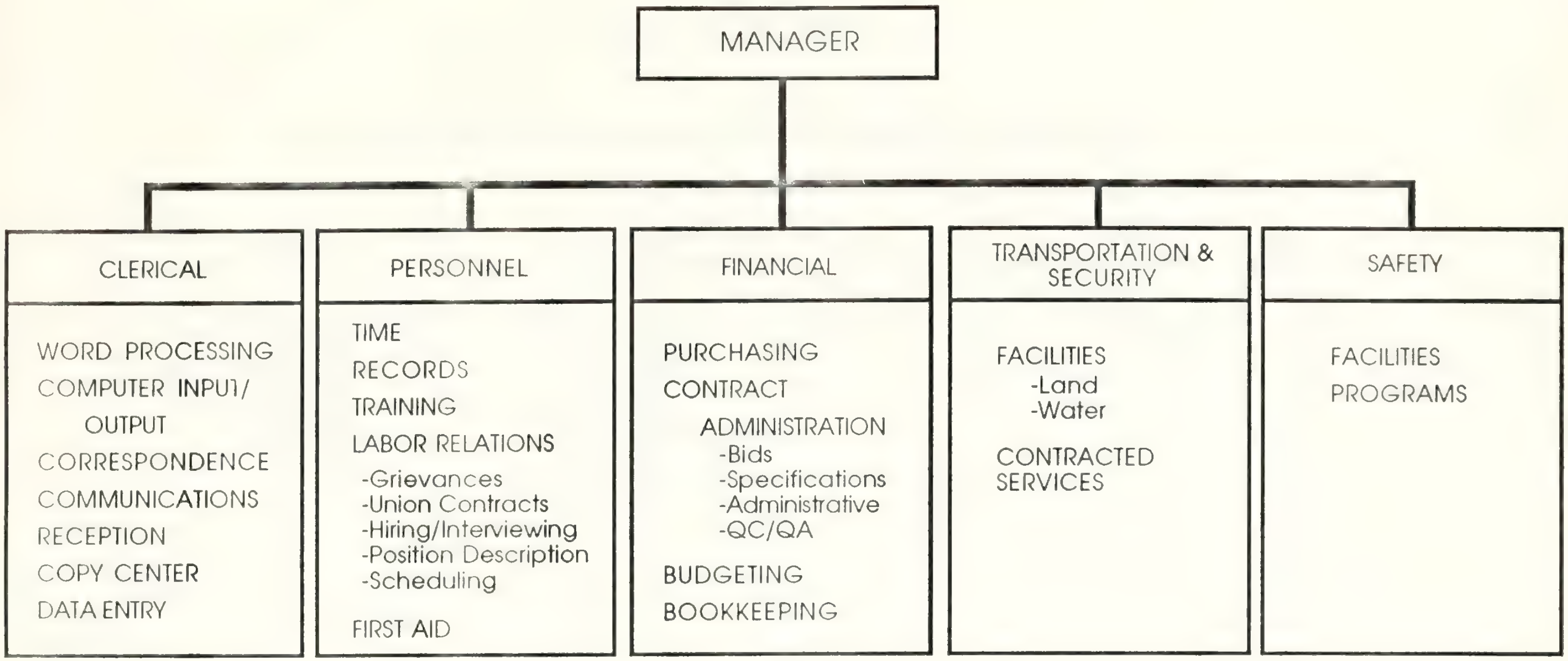
WATER RESOURCES
AUTHORITY

FIGURE G-3
DEER ISLAND WASTEWATER TREATMENT COMPLEX
FUNCTIONAL TABLE OF ORGANIZATION - MAINTENANCE



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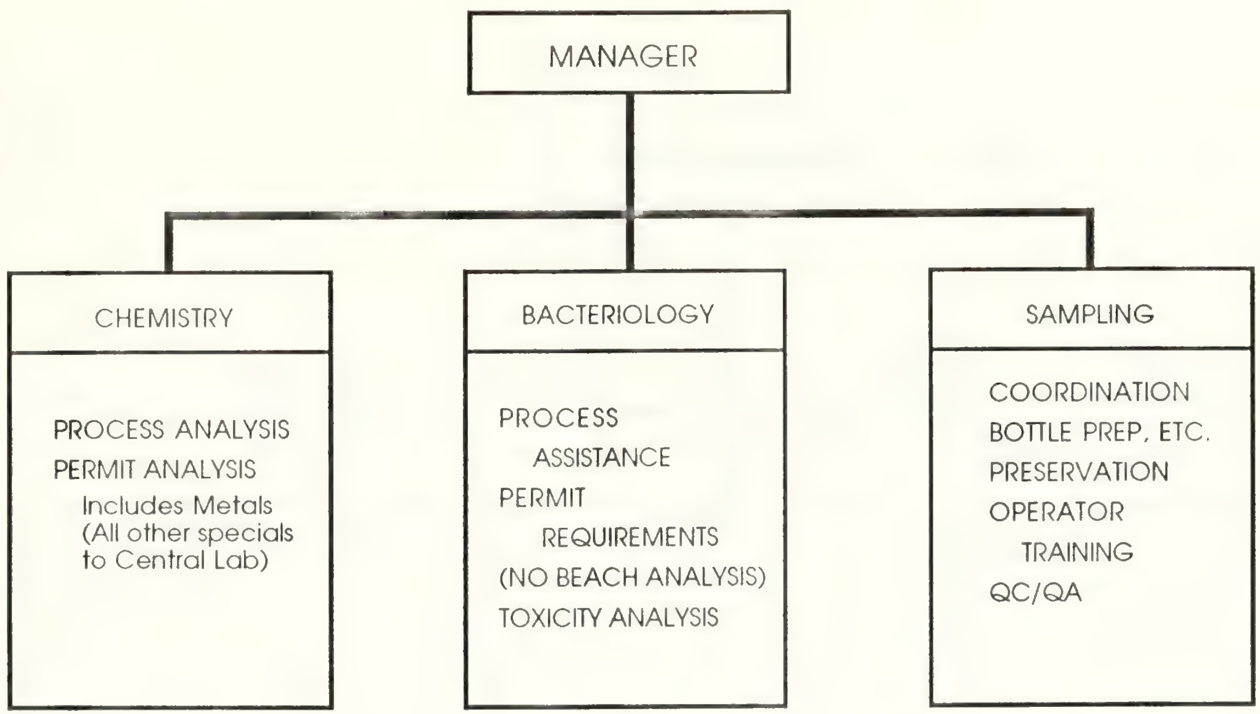
WATER RESOURCES
AUTHORITY

FIGURE G-4
DEER ISLAND WASTEWATER TREATMENT COMPLEX
FUNCTIONAL TABLE OF ORGANIZATION - ADMINISTRATION



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WATER RESOURCES
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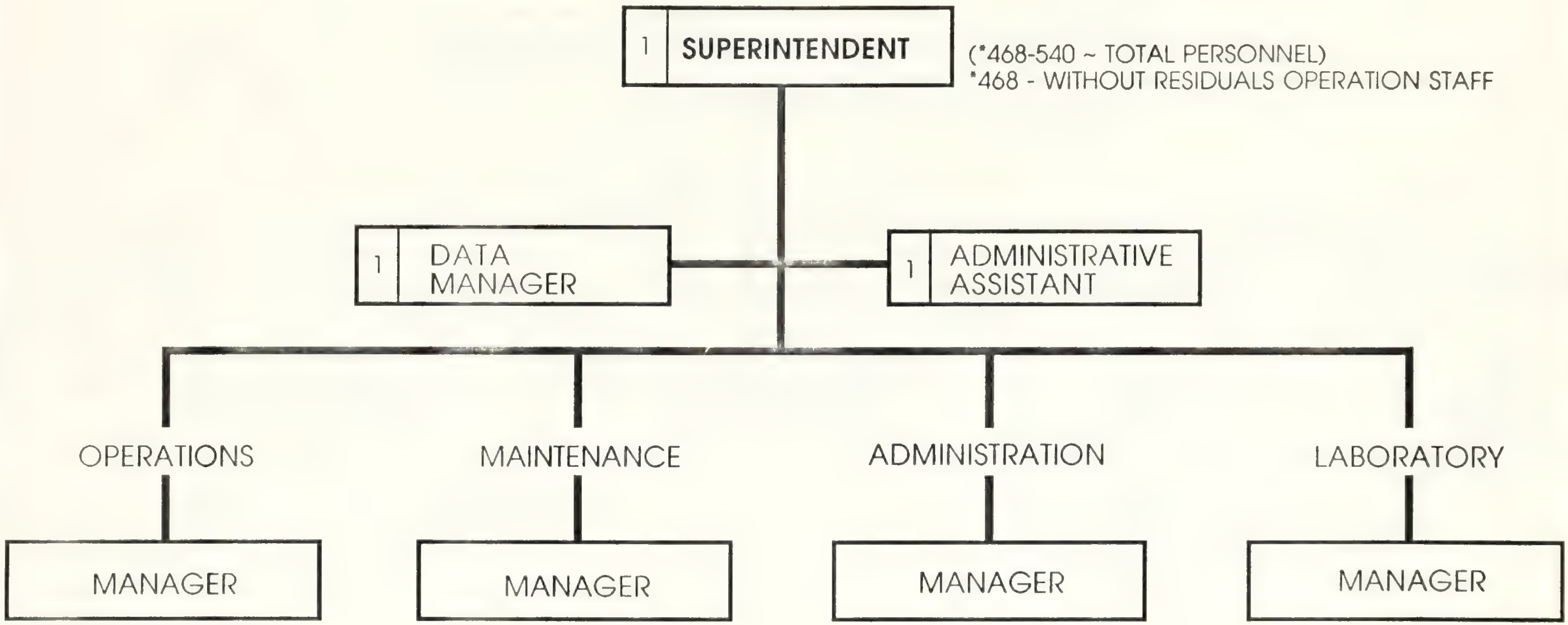
FIGURE G-5
DEER ISLAND WASTEWATER TREATMENT COMPLEX
FUNCTIONAL TABLE OF ORGANIZATION - LABORATORY (Process Only)



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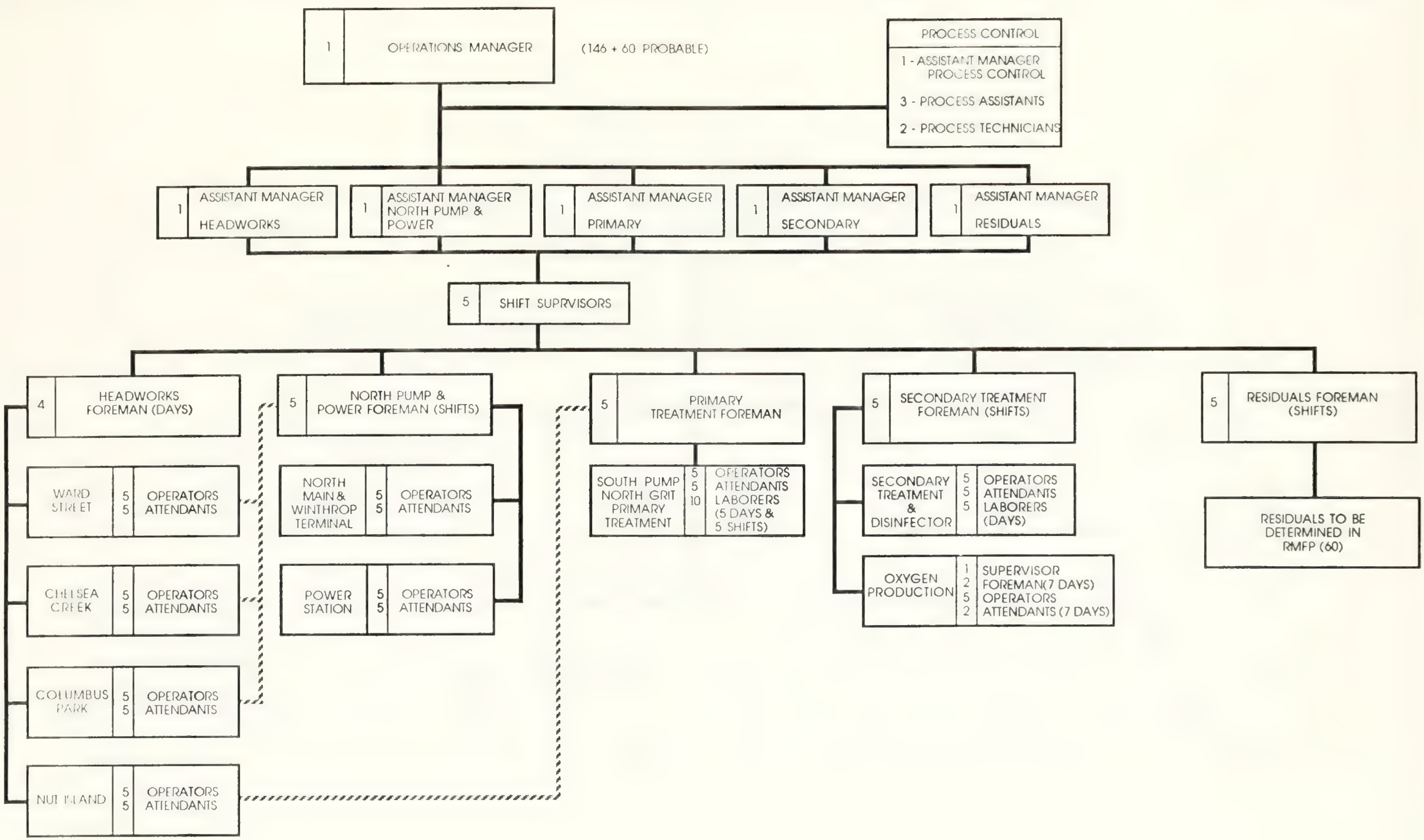
WATER RESOURCES
AUTHORITY

FIGURE G-6
DEER ISLAND WASTEWATER COMPLEX
ORGANIZATIONAL CHART - MANAGEMENT TEAM



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WATER RESOURCES
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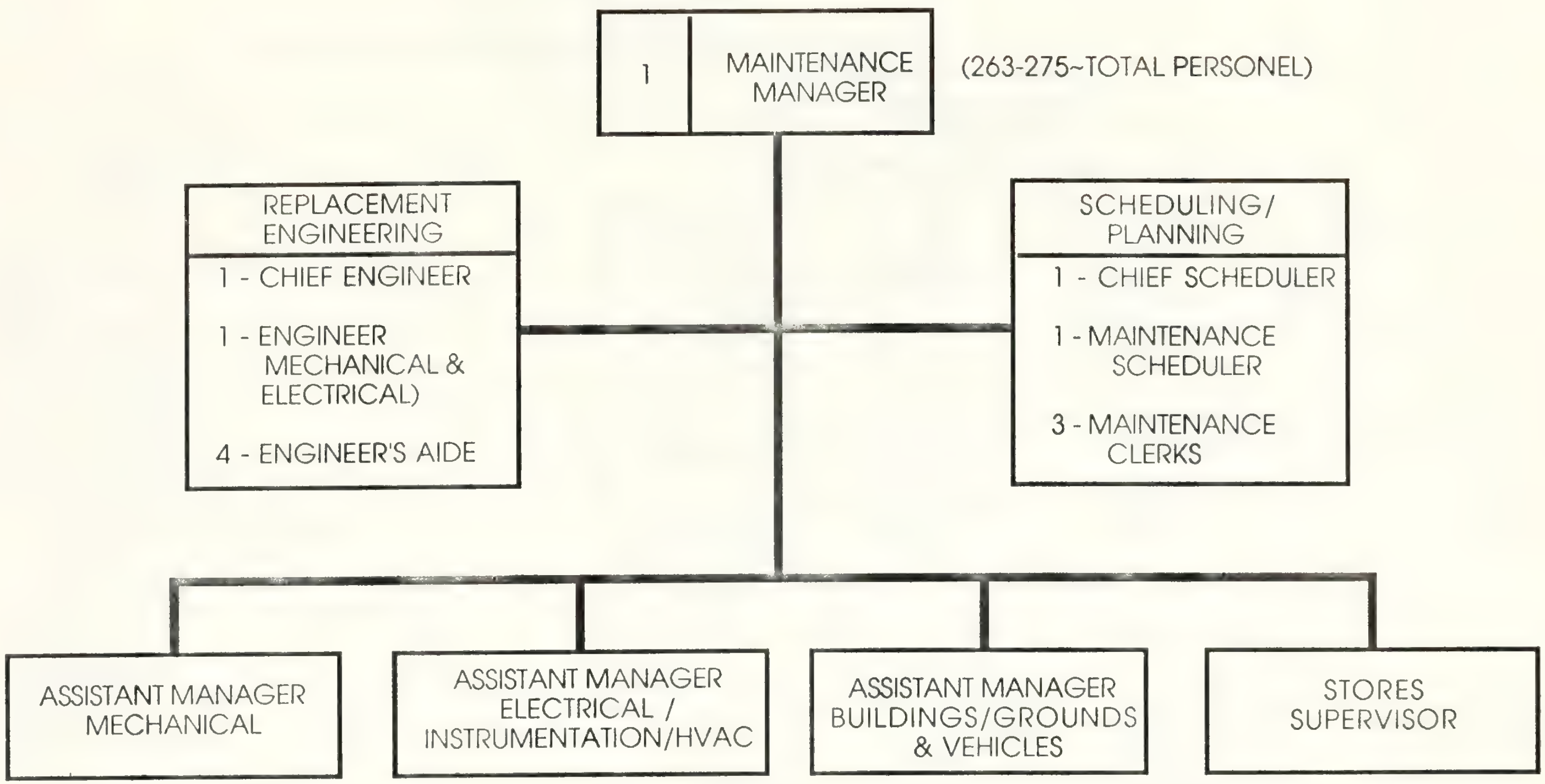
FIGURE G-7
DEER ISLAND WASTEWATER TREATMENT COMPLEX
ORGINAZATIONAL CHART - OPERATIONS



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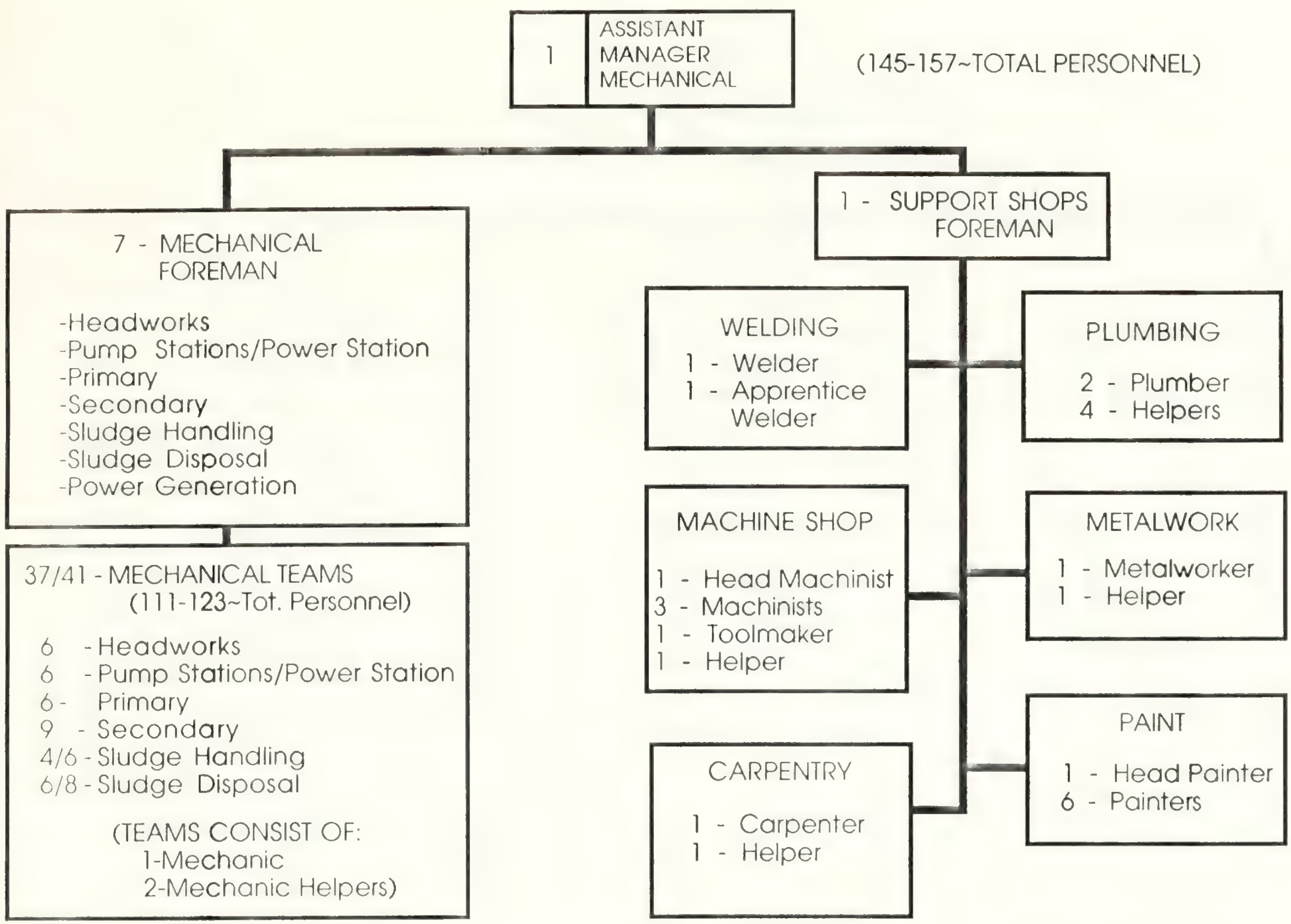
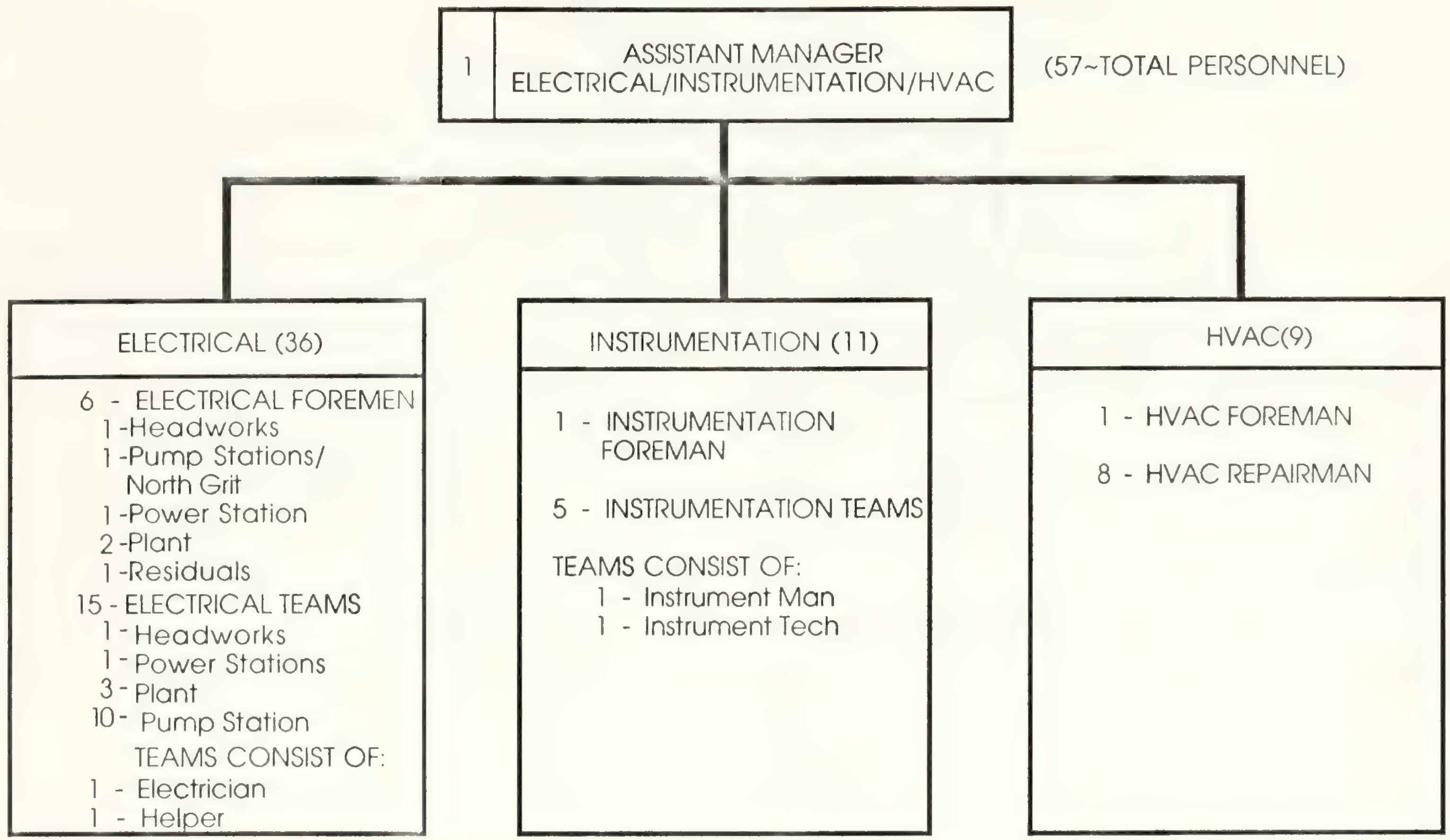
WATER RESOURCES
AUTHORITY

FIGURE G-8
DEER ISLAND WASTEWATER TREATMENT COMPLEX
ORGANIZATIONAL CHART - MAINTENANCE



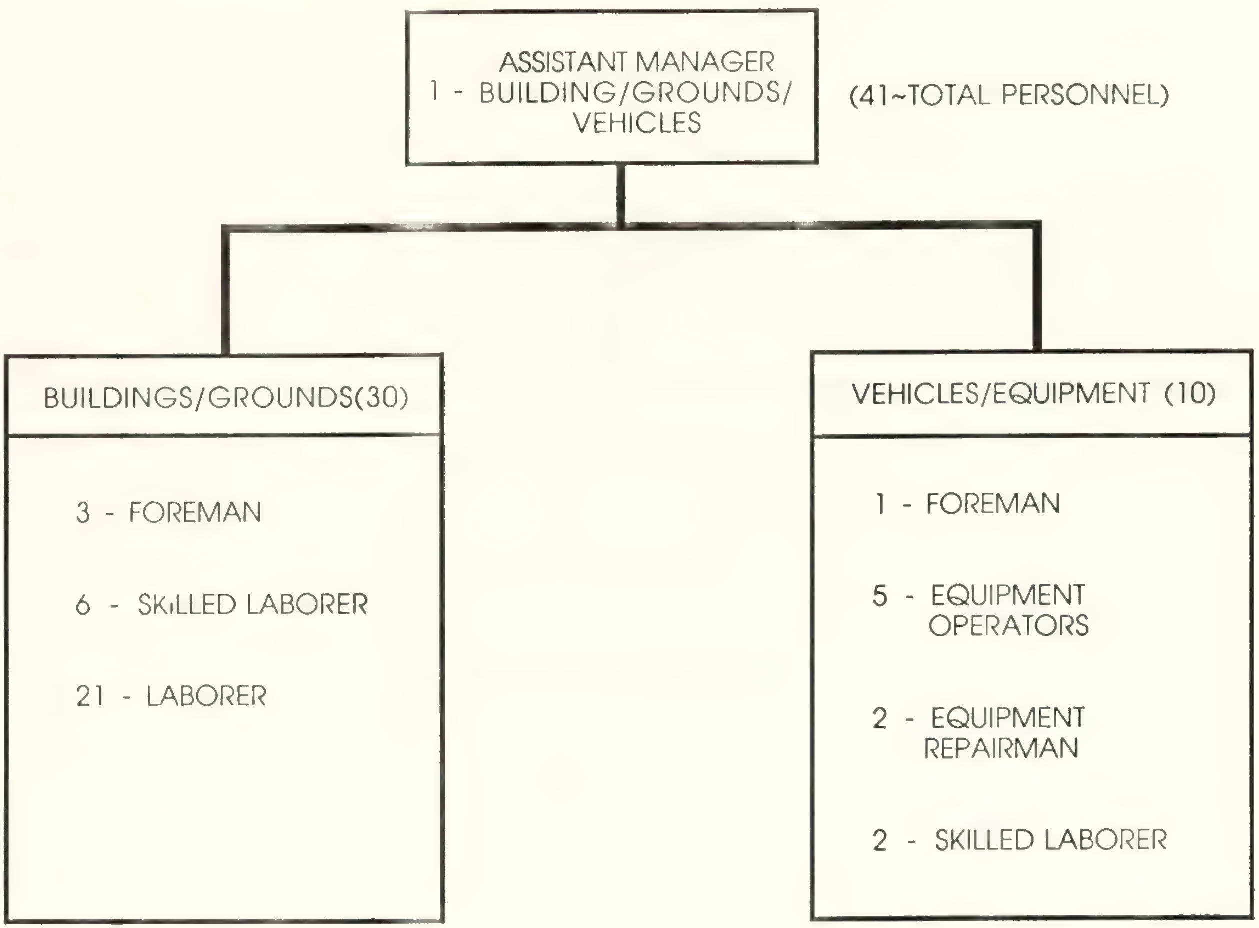
MASSACHUSETTS
WATER RESOURCES
AUTHORITY

FIGURE G-9
DEER ISLAND WASTEWATER TREATMENT COMPLEX
ORGANIZATIONAL CHART - MAINTENANCE - MECHANICAL



MASSACHUSETTS
WATER RESOURCES
AUTHORITY

FIGURE G-10
DEER ISLAND WASTEWATER TREATMENT COMPLEX
ORGANIZATIONAL CHART
MAINTENANCE - ELECTRICAL/INSTRUMENTATION/HVAC



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WATER RESOURCES
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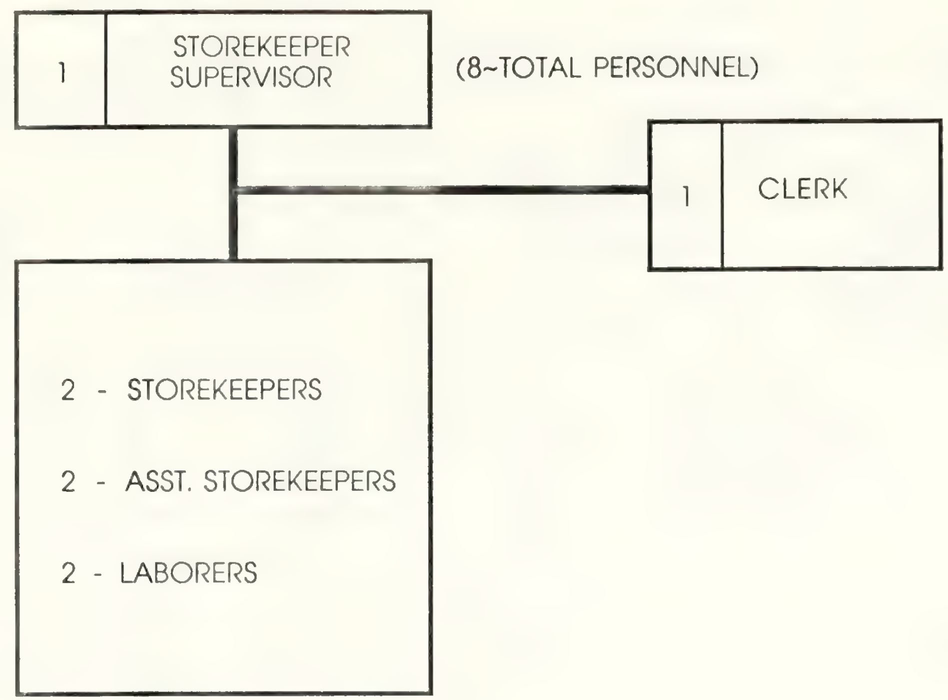
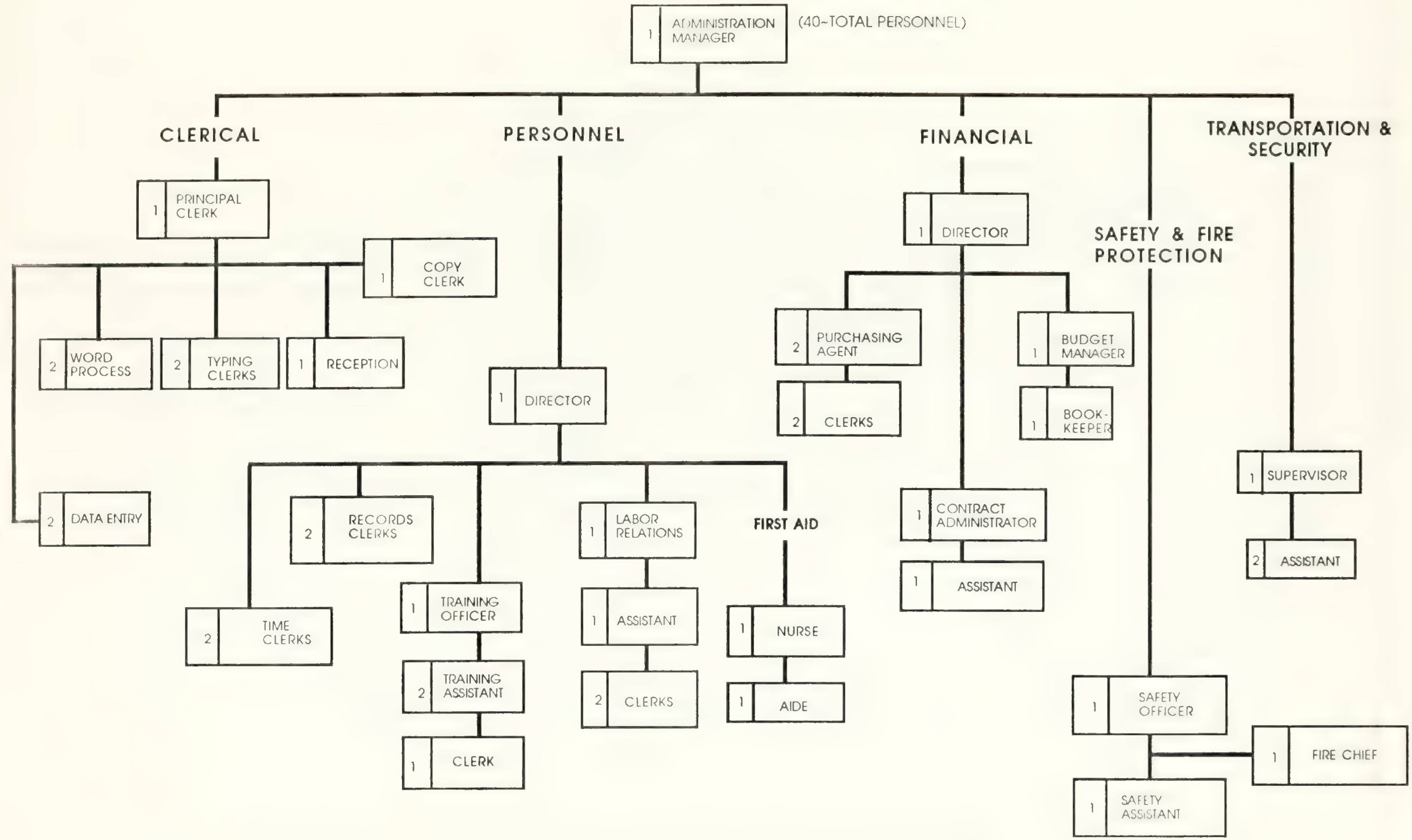
FIG G-11
DEER ISLAND WASTEWATER TREATMENT COMPLEX
ORGANIZATIONAL CHART - MAINTENANCE - BUILDINGS/GROUNDS/VEHICLES



MASSACHUSETTS
WATER RESOURCES
AUTHORITY

FIGURE G-12
DEER ISLAND WASTEWATER TREATMENT COMPLEX
ORGANIZATIONAL CHART - MAINTENANCE - STORES



MASSACHUSETTS
WATER RESOURCES
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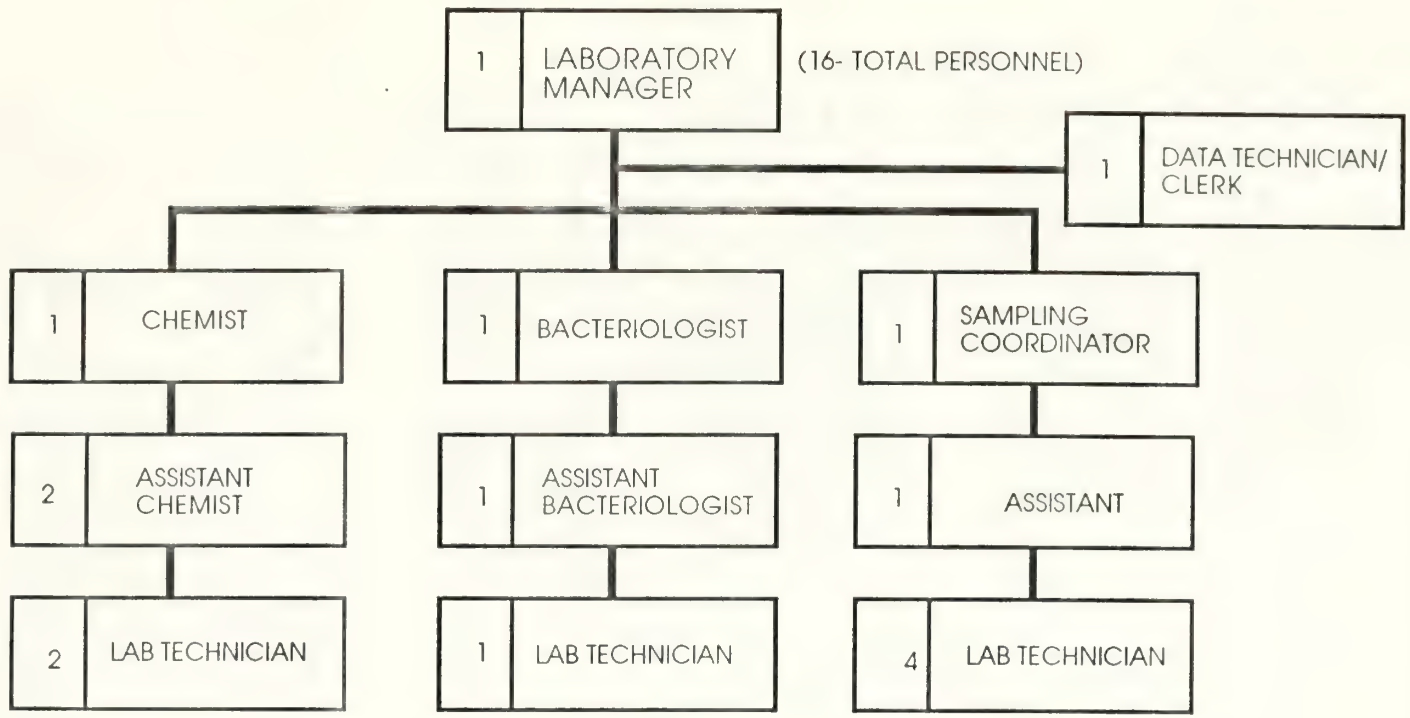
FIGURE G-13
DEER ISLAND WASTEWATER TREATMENT COMPLEX
ORGANIZATIONAL CHART-ADMINISTRATION



* SAMPLING SYSTEM INCLUDING THE HEAD WORKS, IPP AND SLUDGE IS TO BE DETERMINED AT A LATER DATE AND MIGHT EFFECT THIS ORGANIZATION STRUCTURE..

MASSACHUSETTS
WATER RESOURCES
AUTHORITY

FIGURE G-14
DEER ISLAND WASTEWATER TREATMENT COMPLEX
ORGANIZATIONAL CHART-LABORATORY (Process Only)

3. The structure of the teams and sections that establishes a chain of command and potential career path for the individual employees.

4. The structure for holding individual positions accountable for performance.

Discussion of Individual Sections

The Superintendent has two staff assistants and four section managers under his supervision. It is intended that the Superintendent will set the goals, place overall priorities and, in general, plan and direct the Deer Island Facilities through the management staff to accomplish the intended mission and meet the legal requirements of the regulatory permits.

1. The Operations Section (Figure G-7) will operate and control all equipment to accomplish the permit requirements. This includes the four headworks, pumping, grit removal, power generation, primary and secondary treatment of the wastewater, disinfection of the treated wastewater, and concentration, conditioning and disposal of removed residuals.

   The Operations Manager will supervise a process control unit as a staff function and will have five assistant managers under his direction to accomplish the necessary work tasks. The five assistant managers will work through the various foremen assigned to their units to identify work tasks and assign duties to staff personnel to effectively accomplish the unit's goals. The shift supervisors will be informed of the goals and assigned tasks by the assistant managers and will serve as individual shift leaders to coordinate all the group's efforts. The foremen on assigned shifts will work directly with, and assist, the shift supervisors in this coordinating effort.

   The process control staff will be responsible for proper operational direction of the treatment process. This group will serve under the direct supervision of the operations manager. They will be the only group that can direct actual changes in the process control of the facility operations. They will be held accountable by the operations manager for meeting treatment requirements through proper process control directions.

   The operations staff is divided within the units to provide sufficient personnel to accomplish the necessary tasks to achieve effective and efficient operations. It is recommended that the staff, the foremen and the assistant managers be rotated from unit to unit on a regular periodic basis to broaden their skills and improve morale.

2. The Maintenance Section (Figure G-8) is divided into four sub-function specialty units. This section serves as a service staff for the operations section. Their role is to keep all equipment in operating condition so that it is available to the operations section when required. They will provide mechanical, electrical, instrumentation, and HVAC maintenance, buildings and grounds and vehicular maintenance and repair

services. A stores unit has been established to provide tools, supplies, parts, and other necessities for use by personnel in the performance of their duties.

The Maintenance Manager supervises two staff units to assist with special tasks and provide support for the proper functioning of the section. The replacement engineering unit will provide technical support for special maintenance tasks. They will also coordinate and act as an independent support function for Sewer Division central engineering, located in the MWRA central offices. The scheduling/planning group is responsible for the proper functioning of the maintenance management system (MMS). They will receive all maintenance requests, schedule them with one of the four function units' assistant managers, plan any required inter-unit action, check on parts availability, issue and track work orders, and maintain the MMS record system.

The maintenance staff including mechanical, electrical, instrumentation and HVAC maintenance personnel is divided into specialty function units to accomplish the various tasks necessary to ensure availability of equipment needed to achieve proper operations. The various units are divided into teams that provide personnel to accomplish work order assigned tasks. Each of the teams is assigned work by a foreman who will be responsible for the productivity and quality of work performed by the individual teams. The assistant manager's span of control includes only the foreman assigned to his specialty unit, and he will be responsible for accomplishment of tasks by the foreman's assigned teams.

3. The Administration Section (Figure G-13) will support the large staff of the facility by providing on-site administrative services as well as coordination with the MWRA Sewer Division central office administration staff. These administrative services include clerical duties, records control and storage, time-keeping issues, labor relations, training of personnel, first aid services, purchasing, budget management, contracts management, personnel safety, fire protection, and transportation and security coordination.

   The Administration Manager is responsible for these functions and works through five supervisors or directors to accomplish the tasks.

   Each supervisor or director has appropriate staff assigned to accomplish the unit's responsibilities. The clerical unit will provide all reception and clerical services for the facilities. The personnel unit will control timekeeping, labor relations, first aid and training program development. The financial unit controls all purchasing, budget preparation and control and contract development, performance and quality control.

   The safety and fire protection unit will prepare and perform continuous safety program development and execution plus fire protection for the facilities. The transportation and security unit will coordinate all transportation and site security issues.

4. The Laboratory Section (Figure G-14) is established to provide all process control and on-site permit requirement analysis and sampling coordination. They will also provide laboratory data input to the process control unit in the operations section. The section is divided into three functional units (i.e., chemical analysis, bacteriological analysis, and sampling coordination).

   The laboratory manager has a span of control of three unit leaders and has a staff position assigned to input data to the data management system as required.

Position Descriptions

Position descriptions, the guiding concept behind the creation of positions, and what elements and information should be included in position descriptions are discussed in Section 11.5.1 of this plan. A few sample descriptions are included here for illustrative purposes only, as shown on the following pages.

SAMPLE DESCRIPTION - NOT FOR USE

MAINTENANCE MANAGER

GENERAL STATEMENT OF DUTIES

Participates as a part of the Deer Island management team and is responsible for directing the maintenance department, incorporating all mechanical, electrical, instrumentation HVAC, buildings and grounds, and vehicular maintenance of the facilities, including the storeroom for inventories of supplies and parts. Directs the maintenance staff, including the planning and scheduling of all maintenance work both corrective and preventive, and replacement engineering units. Directs the effective use of employees, equipment and material, within an approved budget and quality standard, through assistant managers and supervisors. Participates in plant-wide operational and maintenance coordination activities. Recommends and implements maintenance procedures, and equipment when required. Directs the training of maintenance personnel, resolves personnel problems, grievances and issues when required. Directs preparation of work schedules, and enforces work rules in accordance with established policies and practices. Makes spot inspections of plant equipment throughout the facility to check that standard maintenance procedures are being followed. Responsible for the implementation of safety practices for maintenance personnel. Undertakes special studies and other assignments as required.

SUPERVISION RECEIVED

Works under the direct supervision of the Superintendent.

SUPERVISION EXERCISED

Supervises all maintenance-related personnel through the assistant managers and supervisors and others assigned to the maintenance department from time to time.

EXAMPLES OF DUTIES

- o Directs the mechanical, electrical, and buildings and grounds maintenance of the complex and the support functions of replacement engineering, scheduling/planning and stores.

- o Advises the Superintendent on all matters pertaining to plant maintenance to ensure efficient and economical functioning of all plant facilities and equipment.

- o Reviews the maintenance needs of the plant and develops procedures and programs for accomplishing this maintenance including the preventive maintenance of plant equipment and facilities. Makes personal observations to analyze plant and equipment conditions and recommends corrective measures when and where needed. Investigates, diagnoses, and recommends correction of abnormalities occurring in the plant and plant equipment.

- o Responsible for planning and scheduling the maintenance work of the plant to make maximum and effective use of employees, equipment and material within an approved budget and quality standards.

- o Estimates workforce requirements, and recommends selection of employees necessary to perform the work.

- o Directs the training of maintenance personnel, resolves personnel problems, grievances and other related issues.

- o Makes spot inspections throughout the plant to check that standard maintenance procedures are being followed.

- o Makes inspections throughout the plant to check compliance with the plant safety program and to detect existing or potentially unsafe or unhealthy working procedures, equipment or conditions.

- o Enforces work rules in accordance with established policies and practices.

- o Assists in administering plant fiscal matters and participates in the preparation of reports and budget, reviews maintenance records and data, and develops recommendations.

- o Participates in plant-wide projects aimed at the improvement of plant operations, maintenance and management.

- o Prepares, or directs preparation of, records and reports concerning plant maintenance as required.

- o Establishes procedures for action and recommendations for approval of promotions, merit increases, transfers, leaves of absence, disciplinary measures and other personnel status changes.

- o Trains an understudy to assume the Maintenance Manager's position in the event of his/her absence or promotion.

- o Responsible for the preparation and dissemination of data and reports related to the maintenance department.

SPECIAL DUTIES

None

ENTRANCE REQUIREMENTS AND QUALIFICATIONS

- o A minimum of fifteen (15) years of experience in the maintenance and repair of mechanical equipment similar to that installed in a wastewater treatment plant showing progressive steps of increased responsibility.
- o Must have at least six (6) years of experience as a working supervisor or foreman.
- o Considerable knowledge of the occupational hazards and safety precautions pertaining to all phases of wastewater treatment plant maintenance.
- o Additional work or supervisory experience in managing a maintenance management system is beneficial.
- o Ability to direct a wide variety of maintenance personnel.
- o A thorough knowledge of maintenance systems and procedures in a wastewater treatment facility.
- o Ability to plan, organize, direct and coordinate assigned maintenance projects.
- o Working knowledge of the maintenance of buildings and grounds.
- o A career-minded interest in the maintenance of wastewater treatment facilities.
- o Ability to provide positive leadership and management control to the maintenance personnel by his/her actions and examples.
- o Ability to accept instructions, formulate plans of action, implement changes and ensure their compliance.
- o Must present a neat, courteous and professional appearance and attitude at all times.
- o Must be self-motivated.

SUBSTITUTION

- o A Bachelor of Science or Bachelor of Engineering degree from an approved college or university may be considered a substitute for five (5) years of maintenance experience.

SPECIAL WORKING CONDITIONS

None

SALARY CLASSIFICATION

Non-Union - Supervisory

SAMPLE DESCRIPTION - NOT FOR USE

SHIFT SUPERVISOR

GENERAL STATEMENT OF DUTIES

On an assigned shift, has overall responsibility for the safe and efficient operation of the Deer Island facilities. Supervises a staff of foremen, operators and/or attendants. Oversees adjustment of plant processes as directed by the process control unit. Makes regular inspections throughout the plant to ensure that work is being performed and that standard operating procedures are being followed as assigned by the foreman overseeing that unit of the plant. Has knowledge of condition of all plant equipment in the event of emergency. Participates in the training of operations personnel. Ensures that the Deer Island safety, QA/QC procedures, and work rules are followed in accordance with established practices and procedures. Prepares and checks logs and reports as required. Is responsible for the operation of the complex on shifts as assigned and provides written instructions for meeting the unit goals for process control and work station housekeeping.

SUPERVISION RECEIVED

Works under the direct supervision of the Operations Manager and Assistant Unit Operations Managers.

SUPERVISION EXERCISED

Supervises, on an assigned shift, a staff of foremen, operators and/or attendants. May, on occasion, supervise a number of wastewater treatment plant mechanics and/or laborers.

EXAMPLES OF DUTIES

- o Supervises the operation of the complex following the guidelines established in the Process Control Unit on an assigned shift.

- o Directs the detailed operation and housekeeping tasks through the unit foreman of one of four units of the plant by discussing the process control guidelines, housekeeping schedules, hosing schedules, and log sheets. Evaluates results to assure maximum performance of the facilities and the operator/attendants assigned.

- o Assigns duties to a staff of wastewater treatment plant operators and/or attendants through the unit foreman.

- o Makes regular inspections throughout the plant, to ensure that work is being performed and that standard operating procedures are being followed, to check the operation of the

plant equipment, and to detect existing or potentially unsafe or unhealthy operating procedures, equipment or conditions.

o Prepares, analyzes and routes, according to the Management Information System (MIS), log sheets and reports required to properly control the various units of the plant.

o Reviews and submits maintenance work orders related to equipment malfunctions and unsafe conditions.

o Places into effect, according to the Emergency Operating Plan (EOP), in the event of any emergency, the appropriate corrective procedures to maintain and/or restore operating conditions.

o Participates in the training of foremen, operators/attendants, including instruction in the proper use of safety equipment, first aid kits, oxygen breathing apparatus, resuscitator, firefighting equipment, gas detection devices, etc.

SPECIAL DUTIES

None

ENTRANCE REQUIREMENTS AND QUALIFICATIONS

o At least eight (8) years of full-time, paid experience in positions of increasing responsibility in the operation of wastewater treatment plants, at least three (3) years of which shall be in "direct responsible charge" of an operating shift in a treatment plant of similar complexity.

o Possession of, or eligibility for, a Massachusetts Class VI public sewage treatment plant operator license.

o An interest in the supervision of employees in the operation of a wastewater treatment plant.

o Considerable knowledge and experience in the operation of a wastewater treatment plant with sophisticated treatment and sludge handling processes.

o Ability to supervise a wide variety of personnel and personalities.

o Ability to plan, organize, direct and coordinate assigned projects.

o Must be reliable, thorough, dependable and able to work both independently and as head of a team.

o Must present neat, courteous and professional appearance and attitude at all times.

- o Gives positive leadership to the operations personnel by his/her actions and example.
- o Must be extremely safety-conscious when performing duties.
- o Must be able to accept instruction, formulate plans of action, and ensure their compliance.
- o Must be in good physical condition.

SUBSTITUTION

- o Successful completion of three (3) years of full-time, or equivalent part-time training, in a recognized technical institute or college with courses in the area of water and wastewater technology may be substituted for the required experience on the basis of one full school year for one year of the required experience.

SPECIAL WORKING CONDITIONS

Under normal and abnormal working conditions, there is the possibility of exposure to weather, fumes, odors, dust, toxic gases and chlorine.

SALARY CLASSIFICATION

Non-Union - Supervisory

SAMPLE DESCRIPTION - NOT FOR USE

OPERATOR

GENERAL STATEMENT OF DUTIES

Under minimal supervision, on an assigned shift, has responsibility for performing operational procedures, minor maintenance and housekeeping tasks at the treatment and pumping facilities. Collects wastewater samples, maintains required log sheets, and operates a wide variety of mechanical and electrical equipment used in the treatment processes. Makes regular and scheduled inspections throughout the assigned area, recognizes, corrects or reports potential interruption/failure of equipment or process to the shift or headworks foreman. Performs and/or assists shift foreman in operational procedures during emergency conditions. Responsible for the good housekeeping of equipment and buildings in the assigned area.

SUPERVISION RECEIVED

Works under the direct supervision of the Shift or Headworks Foreman.

SUPERVISION EXERCISED

None.

EXAMPLES OF DUTIES

- o Operates wastewater treatment and sludge processing equipment to control wastewater and sludge flow streams to maintain effluent compliance standards.
- o Collects composite and grab samples as instructed.
- o Maintains shift log and records meter and gauge readings.
- o Monitors and observes variations in operating conditions and interprets meter, gauge readings, control panels and test results to determine processing equipment requirements.
- o Operates valves and gates either manually or by remote control; starts and stops pumps to control and adjust flow and treatment processes.
- o Manually operates and uses rakes, shovels, forks, and other similar tools in collecting and removing trash, screenings, grit and other materials from the wastestream to collection bins for disposal.
- o Assists shift supervisors and shift foreman in controlling the wastewater treatment process during routine and emergency conditions.

- o Performs the application and preparation of chemical solutions and the operation of chemical equipment and appurtenances in accordance with needs.

- o Makes inspections as required to observe and check the operation and condition of equipment; detect and report faulty equipment operation, malfunction and/or breakdowns to the shift or headworks foreman.

- o Responsible for the good housekeeping of equipment and buildings in the assigned area as well as other employee areas of the facility.

- o Assists in the loading/unloading of chemical and other deliveries.

- o Follows the established safety procedures.

- o Follows the established QA/QC procedures for sample collections.

- o Ensures that safety instruments and equipment under his/her care are maintained in working order, cleaned and stored properly.

- o Prepares and submits maintenance work orders relating to equipment malfunctions and unsafe conditions to the shift foreman, as a part of the Maintenance Management System (MMS).

- o Performs related duties as assigned.

SPECIAL DUTIES

Volunteer Firefighter

ENTRANCE REQUIREMENTS AND QUALIFICATIONS

- o At least five (5) years of full-time paid experience in positions of increasing responsibility in a wastewater treatment facility.

- o Possession of a Massachusetts Class III public wastewater treatment plant operator license.

- o Previous experience in a water or wastewater treatment facility or related industry highly preferred.

- o Previous education or training in a recognized technical institute or college in an area of study or training related to wastewater treatment operations is highly preferred.

- o Must present a neat, courteous and professional appearance and attitude at all times.

o Must be able to follow oral and written instructions.

o Must be self-motivated.

SPECIAL WORKING CONDITIONS

Under normal and abnormal working conditions, there is the possibility of exposure to weather, fumes, odors, dust, toxic gases and chlorine.

SALARY CLASSIFICATION

Union

SAMPLE DESCRIPTION - NOT FOR USE

LABORER

GENERAL STATEMENT OF DUTIES

Performs heavy manual tasks requiring some specialized skills or knowledge in one or more of the mechanical trades; performs related work as required. Works in accordance with established work and safety practices.

SUPERVISION RECEIVED

Works under the supervision of employees of higher grade, including foreman, mechanics, electricians, storekeeper/scheduler, operators, and other personnel assigned.

SUPERVISION EXERCISED

None

EXAMPLES OF DUTIES

1. Performs heavy manual tasks requiring some specialized skill or knowledge.

2. Assists mechanics, operating personnel or other tradesman engaged in the maintenance and operation of the treatment plant and related facilities.

3. Removes trash and other debris to storage hoppers; maintains work area and equipment in a clean and orderly condition.

4. Loads, unloads, moves and transports materials, equipment, freight and supplies; assists in the handling and storage of stock.

5. Operates motor vehicles, hoists and portable equipment as required; cleans, washes, gases, oils and greases vehicles and equipment.

6. Works on grounds, buildings and roadways; sands roads and walkways; cleans drains, manholes and sumps.

7. Cuts, fertilizes, waters, trims, rolls and rakes lawns; prunes trees and shrubs.

8. Works on snow removal team during and after snow storms.

9. Assists in the upkeep of buildings and grounds.

10. May erect and work from scaffolding and ladders.

11. Performs other duties as assigned.

SPECIAL DUTIES

Volunteer Firefighter

ENTRANCE REQUIREMENTS

1. Ability to perform tasks that are assigned by supervisors.

2. Experience in labor tasks highly preferred.

3. Must possess a valid driver's license and a safe driving record.

4. Some knowledge of the use of common hand tools.

5. Some knowledge of construction and maintenance materials.

6. Ability to operate power saws, winches, cement mixers, compressors and other similar equipment.

7. Ability to operate automotive trucks and equipment.

8. Must have the ability to perform manual labor for extended periods and under varying climatic conditions.

9. Must be reliable, thorough and dependable with the ability to work both independently and as part of a team.

10. Must present a neat, courteous, and professional appearance and attitude at all times.

11. Must receive directions well and be willing to learn.

12. Ability to successfully carry out detailed oral and written instructions.

13. Must be thoroughly safety conscious when performing duties.

14. Must be self-motivated.

SPECIAL WORKING CONDITIONS

Under normal and abormal working conditions, there is the possibility of exposure to weather, fumes, odors, dust, toxic gases and chlorine.

SALARY CLASSIFICATIONS

Union

SAMPLE DESCRIPTION - NOT FOR USE

MECHANIC

GENERAL STATEMENT OF DUTIES

Performs the inspection, overhaul, repair, testing and maintenance of a wide variety of mechanical equipment. Implements corrective maintenance and preventive maintenance procedures. Recommends and implements improvements and modifications to plant machinery and equipment. Performs tasks requiring some specialized skill or knowledge relating to the maintenance or operations of the treatment plant and related facilities. Works in accordance with established work and safety practices.

SUPERVISION RECEIVED

Works under the direct supervision of a Mechanical Foreman.

SUPERVISION EXERCISED

Supervises one or more Mechanic Helpers, Laborers, or others assigned as helpers.

EXAMPLES OF DUTIES

1. Performs the rebuilding and maintenance of flights, chains, belts, sprockets, shafts, bearings and rails of sludge, grit, scum collecting and conveying systems as used in sedimentation tanks, mechanically-cleaned bar screens and other plant processes.

2. Overhauls pumps, renews pump components, repacks stuffing boxes, replaces shafts, bearings, couplings and packings.

3. Cleans, overhauls and maintains pumps, chlorination equipment and telescoping sludge valves; renews ball bearings, lubricant seals and retainers; overhauls motor reduction gears; renews internal parts as directed.

4. Cleans, overhauls and maintains chemical feed equipment, eductors, vibratory feeders, mixers, rotary gate valves, and chemical solution feed pumps.

5. Overhauls, removes and maintains shaft type couplings as well as pneumatic members, rubber bushings and spiders, in an approved manner.

6. Assists in overhaul and maintenance of engines; changes lubricants and filters at scheduled intervals; renews internal shafts, gears, bearings, bushings, retainers and seals as directed.

7. Maintains and repairs gas and air compressors, reduction gears, boilers, oil and gas burners, chlorine feeding equipment, valves, heat exchangers, centrifugal pumps, air or gas storage tanks, portable gasoline engine powered pumps, compressors and welders.

8. Maintains plant automotive, truck and snowplow equipment as assigned.

9. May erect and work from scaffolding and ladders.

10. Performs other duties as assigned by the supervisor.

SPECIAL DUTIES

Volunteer Firefighter

ENTRANCE REQUIREMENTS AND QUALIFICATIONS

1. A minimum of five (5) years' training and experience in the maintenance and repair of heavy mechanical equipment as used in a wastewater treatment plant.

2. Must have served an 8,000 hour state approved mechanical apprenticeship program or equivalent.

3. Considerable knowledge of the occupational hazards and safety precautions pertaining to all phases of plant maintenance.

4. Must be able to read blueprints.

5. Must be able to operate shop equipment including drill presses and other standard machine shop tools.

6. A career-minded interest in the maintenance and repair of mechanical and electrical equipment.

7. Considerable knowledge of the proper use of hand and power tools.

8. Ability to perform orderly disassembly and reassembly of complex precision machinery and components.

9. Ability to properly supervise others assigned as helpers.

10. Strength and agility necessary to maintain and repair heavy, crude machinery.

11. Knowledge of rigging, hoisting and tackle procedures.

APPENDIX H

ENERGY

<u>READER'S GUIDE TO APPENDIX H, ENERGY</u>

This report includes two separate sections. "Appendix H - Deer Island" is a comprehensive report dealing with the major energy demands and required facilities at Deer Island. "Appendix H - Nut Island" addresses the much smaller energy demands at Nut Island.

Appendix H - DEER ISLAND

1.0 SUMMARY

This report presents the results of a study of primary and backup energy supply alternatives for the Massachusetts Water Resources Authority's (MWRA) Deer Island secondary wastewater treatment plant. This study of alternatives is necessary to provide the basis for detailed design and construction of energy supply facilities to ensure that a reliable and economic power supply is available to support the construction and timely start-up of new and rehabilitated treatment facilities.

This study was performed by preparing an estimate of the energy requirements over several phases of the project and developing and evaluating alternative approaches to satisfy these requirements. Evaluations were performed for off-site and combined on-site/off-site energy supply alternatives using technical, economic, and environmental evaluation criteria. Energy supply alternatives were evaluated with and without on-site sludge digestion to determine the sensitivity of the results to the use of digester gas as supplemental fuel. The use of on-site sludge digestion and its associated costs and benefits will be determined as part of the Residuals Management Facility Plan.

The estimated energy demands are based on increased energy usage resulting from the addition of secondary treatment as well as the addition of the Nut Island wastewater flows to the Deer Island treatment facilities. The energy demand projections also reflect the phased construction and operation of the primary treatment facilities (beginning in 1995) and the secondary treatment facilities (beginning in 1999). For purposes of this analysis, it was assumed that total influent generated by member communities is an average of 300 million gallons per day (mgd) at present, and will increase to 333 mgd in 1988 and 485 mgd in 1995 when the South System flow is added to Deer Island.

Assessments of air quality and noise impacts are included to evaluate compliance with regulatory requirements and/or to identify potential environmental constraints on alternatives.

1.1 EXISTING FACILITIES

The existing Deer Island treatment plant is not connected to the local utilities grid; all power currently consumed on Deer Island is generated on-site. The existing power-generating facilities at Deer Island consist of five 700 kw Enterprise diesel generator sets with dual-fuel (fuel oil/digester gas) capability. These units will be rehabilitated under the fast-track improvements projects, extending their life until 1995. Two new 6-MW dual-fuel diesel generator sets will also be added under the Fast-Track Improvements Program to support a 50-percent influent pump electrification.

The Deer Island treatment plant Main Pumping Station includes nine, 90-mgd sewage pumps, eight of which are driven by Nordberg diesel engines. The ninth is electric motor-driven, drawing power from the Enterprise engines. Under the Fast-Track Improvements Program, three Nordberg

engine-driven pumps will be retired in 1988 and replaced with electric motor-driven pumps. An additional electric motor-driven pump will be installed in the spare-pump position. The other five Nordberg engines will remain in service through 1994 and will then also be replaced with new electric motor-driven pumps as part of the new primary treatment plant construction program.

At the Winthrop Terminal headworks, there are four electrical-driven 15-mgd sewage pumps and two diesel-driven pumps rated at 60 mgd. The diesel drives will be replaced with motor drives as part of the Fast-Track Improvements Program.

1.2 ENERGY DEMAND PROJECTIONS

Table H-1 shows the estimated peak power demands for the years 1987 to 1999 for the Deer Island facility together with the committed (existing or already planned) capacity discussed above. These power requirements are based on total electrification of the influent pumping station and new treatment facilities. The demand or need increases in a stepped manner from current peak, cumulative electric demands of 2,150 kw to 45,200 kw in 1995 (full primary treatment of both North and System Systems), and 64,225 kw in 1999 (secondary treatment). Based on historical pumping profiles, a preliminary power-load duration curve was developed, as shown in Figure H-1, to characterize hourly electric energy consumption. Estimates of thermal energy demand were developed for heating buildings and pipe galleries in each alternative and for heating sludge in the anaerobic digester alternatives.

1.3 POWER SUPPLY ALTERNATIVES

During the preliminary power supply alternatives study, three options were considered. The first was to purchase all additional energy, primary plus backup, from a local utility. The second was to add sufficient generating capacity to meet the entire requirement with the largest unit out of service, which would require no connection with the local utility. The third involved purchasing all energy from a single source and adding sufficient generating capacity to supply all required energy should the tie with the utility fail in service.

At the time that the Preliminary Energy Report was discussed with the MWRA Board of Directors, the Board voted to eliminate Alternative 2 (i.e., 100 percent on-island generation of Deer Island power requirements). This alternative, was, therefore, deleted from further consideration. It was further decided that meetings would be held with both Boston Edison Company (BECo) and Massachusetts Electric Company to determine which could satisfy both the peak demand and EPA's reliability criterion, which requires the provision of power from two separate sources to meet uninterrupted critical service needs. Deer Island is currently within BECo's licensed service area.

Based on the vote of the MWRA Board and the estimated power demands, the following basic power supply alternatives (Alternatives 1 and 3) for primary and backup power for Deer Island were considered further.

TABLE H-1

PRELIMINARY POWER NEEDS OF SECONDARY TREATMENT FACILITIES PLAN

Year	Description of power needs	Incremental increase to average load (kw) period	Cumulative average load (kw)	Peak load (kw) period	Cumulative peak load (kw)	Cumulative installed capacity (kw)	Cumulative secure capacity* (kw)	Cumulative shortfall (kw)
1986	One electrified influent pump	1,500		1,500		3,500	2,800	
1986	Basic power usage	650	—	650	—	—	—	—
			2,150		2,150	3,500	2,800	0
1988	Electrification of four influent pumps (additional) and Winthrop terminal pumps	2,500	—	7,200	—	12,000	6,000	—
			4,650		9,350	15,500	8,800	550
1990	Construction power	10,000	—	15,000	—	0	0	—
			14,650		24,350	15,500	8,800	15,550
1991	Primary sludge-dewatering, piers and basic power	4,000	—	4,500	—	0	0	—
			18,650		28,850	15,500	8,800	20,050
1995	Primary treatment and basic power usage	7,800		9,400				

TABLE H-1

PRELIMINARY POWER NEEDS OF SECONDARY TREATMENT FACILITIES PLAN
(Continued)

Year	Description of power needs	Incremental increase to average load (kw) period	Cumulative average load (kw)	Peak load (kw) period	Cumulative peak load (kw)	Cumulative installed capacity (kw)	Cumulative secure capacity* (kw)	Cumulative shortfall (kw)
	Electrification of five influent pumps, Winthrop terminal pumps and South System flows	4,100		17,700		-3,500	-2,800	
	Air emissions control	500		1,250				
	Disinfection (NaOCl purchased)	**		**				
	Construction power	-7,000	24,050	-12,000	45,200	12,000	6,000	39,200
1999	Secondary facilities and basic power usage	13,500		19,400				

*Secure capacity is that capacity which, because it is provided from two separate sources, is considered to be totally reliable in accordance with EPA criterion as specified in EPA Technical Bulletin EPA-430-99-74-001.

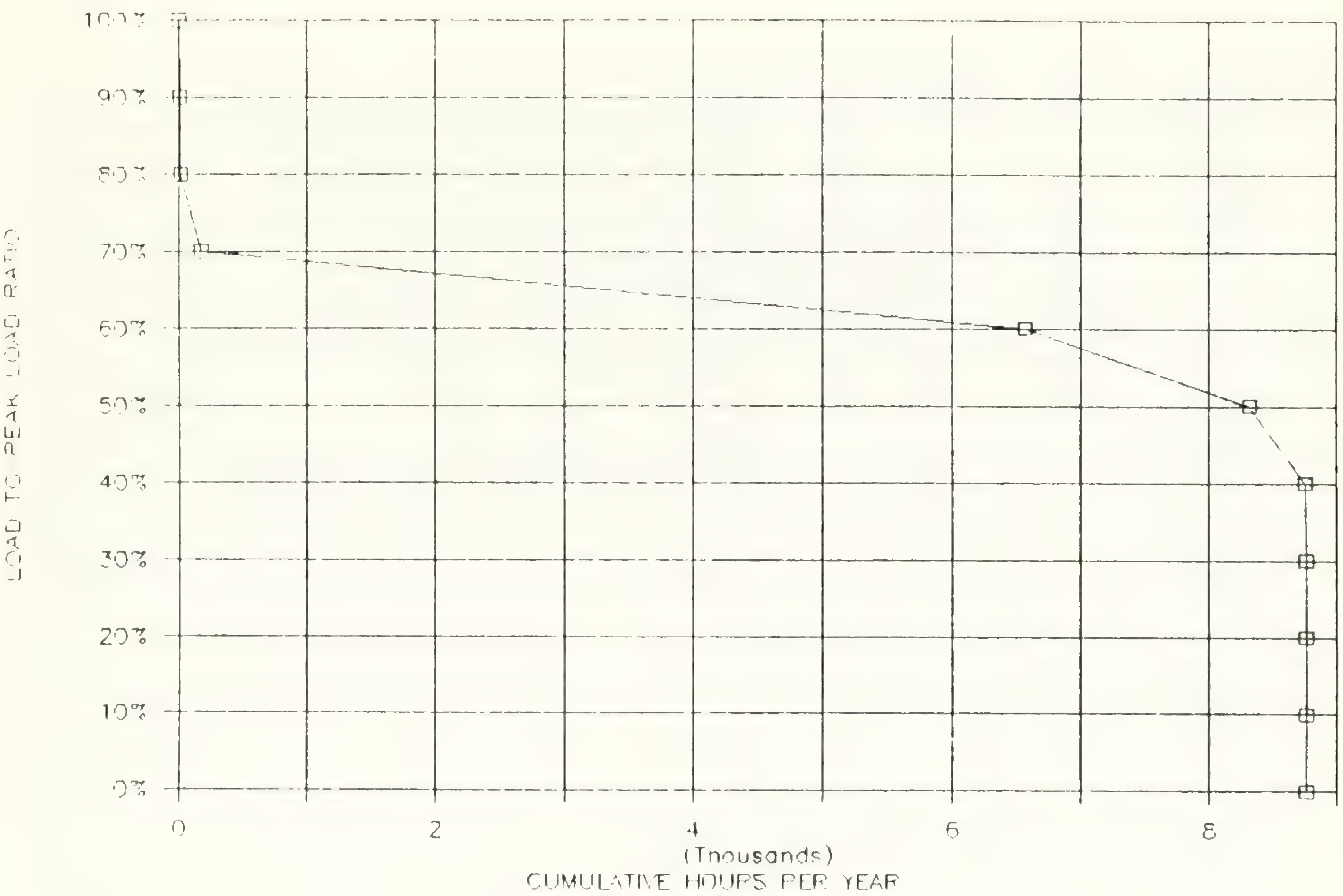
TABLE H-1

PRELIMINARY POWER NEEDS OF SECONDARY TREATMENT FACILITIES PLAN
(Continued)

Year	Description of power needs	Incremental increase to average load (kw) period	Cumulative average load (kw)	Peak load (kw) period	Cumulative peak load (kw)	Cumulative installed capacity (kw)	Cumulative secure capacity* (kw)	Cumulative shortfall (kw)
	Additional air emissions control	250		625				
	Sludge processing	2,000		2,000				
	Disinfection (NaOCl purchased)	**		**				
	Construction power	-3,000		-3,000				
			36,800		64,225	12,000	6,000	58,225

* Secure capacity is that capacity which, because it is provided from two separate sources, is considered to be totally reliable in accordance with EPA criterion as specified in EPA Technical Bulletin EPA-430-99-74-001.

** Included in Basic Power.



MASSACHUSETTS
WATER RESOURCES
AUTHORITY

FIGURE H - 1
LOAD DURATION CURVE

Alternative 1: Off-site Purchase. BECo would supply most of Deer Island's power requirements via a dedicated transmission line from its K Street substation. A duplicate transmission line from its Chelsea substation would be provided for backup. No additional on-site generating capacity beyond the two 6 MW dual fuel diesels is proposed.

This alternative requires the installation of two trans-harbor submarine cables from independent BECo substations to meet the electrical power redundancy requirements for the project. Cable construction would require environmental reviews and permits. For the purpose of this study, it was assumed that BECo would design, license, and install these cables, while MWRA would construct the on-island substation. In a September 1987 meeting, however, BECo indicated a willingness to consider owning and operating the high-voltage portion of the on-island substation; MWRA would still be responsible for the low-voltage side of the substation and the distribution system. The cost to MWRA for the high-voltage portion would then be reflected in the electric rates plus upfront capital payments for the backup line. It may also be possible to pay for the two cables and the electrical substation with funds from the Construction Grant Program. This should be a subject of future negotiations with BECo; a possible outcome could be a sharing of the initial capital investment and reduced electric rates. Environmentally, increased operation of existing on-site capacity units must be evaluated in terms of potential increases in emissions above the baseline yet to be determined by the Massachusetts Department of Environmental Quality Engineering (DEQE).

Alternative 3: Combined On-site Generation and Off-site Purchase. Purchased power from BECo, and/or on-site power generation capacity, would be dispatched economically to meet 100 percent of Deer Island's power requirements. Unless the on-site power plant has sufficient capacity to meet the 1999 peak shortfall of 58 MW, a second cable power supply with sufficient capacity to operate the entire plant should also be provided as backup to the primary supply. This alternative requires cable connections with BECo similar to those discussed for Alternative 1 and also includes additional on-site capacity.

The impact of these additions of on-site capacity on air quality and noise levels have been evaluated using emissions information currently available. This information includes an estimate of the Deer Island baseline emissions and the predicted future emissions, except for NO_x, based on EPA guideline AP-42 (Compilation of Air Pollution Emission Factors, Volume 1, Stationary Point and Area Sources, 4th Edition, October 1986). Generating units included in this preliminary analysis are provided with commercially available NO_x emissions and noise controls typically provided for such equipment, and some fuel-type limitations are assumed. For example, gas turbines include water or steam injection to reduce NO_x emissions; diesels will burn a maximum 0.3 percent sulfur diesel fuel; and diesels and gas turbines will be enclosed with standard silencing provisions on intakes and exhausts. Specific controls will be evaluated in the detailed engineering and design phase.

AP-42 is useful for study purposes because it is a generic (non-vendor specific) guideline acceptable to regulatory agencies and its use generally results in conservatively high emission predictions. However, a review of manufacturers' data indicates that actual emissions may be significantly lower. Therefore, during detailed design and permitting, a more detailed air

quality assessment should be performed using vendor specific data and a baseline approved by the State.

1.4 RESULTS

The off-site power supply evaluated in both alternatives consisted of a primary 115-kv submarine cable supplied from BECo's K Street substation and, as required, a back-up 115-kv underground and submarine cable brought in through East Boston and Logan Airport and supplied from a BECo substation in Chelsea. When providing off-site power from two separate sources, no on-site generation is required to meet the reliability criterion as specified in EPA Technical Bulletin EPA-430-99-74-001.

For the combined on-site generation and off-site purchase alternative (Alternative 3), combinations of on-site generation capacity with single and dual off-site supplies were developed. The options considered under Alternative 3 were:

- o A single off-site supply, consisting of a 115 kv cable from BECo's K Street substation; plus, a 58 MW combined cycle power plant, consisting of two gas turbines, each with its own supplementary fired heat recovery boiler, and a single condensing steam turbine;

- o Dual off-site supplies consisting of a 115 kv cable from BECo's K Street substation and a 115 kv cable from BECo's Chelsea substation plus a 25.7 MW combined cycle power plant;

- o Dual off-site supplies consisting of the two 115 kv cables from BECo, plus a 15 MW combined cycle power plant.

Each Alternative 3 option is capable of handling critical loads with both the primary off-site source and the largest on-site generating unit out of service. In all cases, credit was taken for existing and committed on-site capacity through its planned service life.

It was determined that, although not required to meet the EPA reliability criteria, additional on-site generating capacity is economically beneficial and provides additional protection against total offsite power failure. In all cases under Alternative 3, sufficient capacity to share the peak load results in the most economical operating conditions. The additional on-site generating capacity of 25.7 MW was found to be the most cost effective alternative based on the estimated load projections and economic assumptions included in this report. Furthermore, the total recommended on-site capacity of 25,700 kw of new capacity plus the 12,000 kw of capacity already committed will provide sufficient power to keep primary treatment in service in the event of a total power failure, such as the 1965 Northeast blackout. Since the 15 MW combined cycle plant option offerred no other benefits, it was dropped from further consideration.

The on-site generating capacity will tie into the electrical substation, as shown on the electrical one-line diagram which is Figure H-2. An arrangement of the 25.7 MW powerhouse and

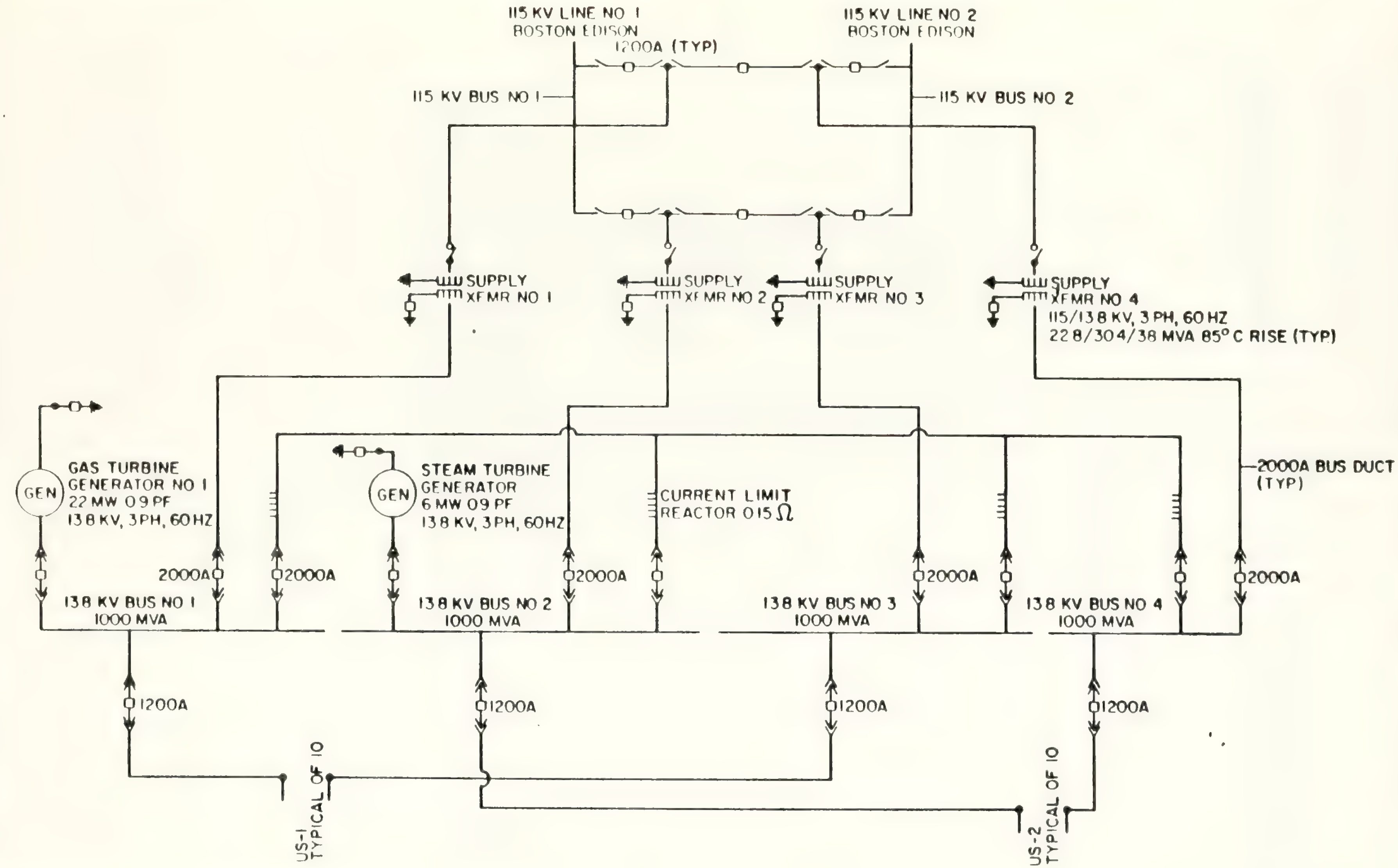


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FIGURE H - 2
ELECTRICAL ONE LINE DIAGRAM
POWER SUPPLY

electrical substation is shown on Figures H-3, H-4, H-5, and H-6. The fundamental flow diagram in Figure H-7, is a schematic respresentation of the manner in which power and steam for heating will be generated.

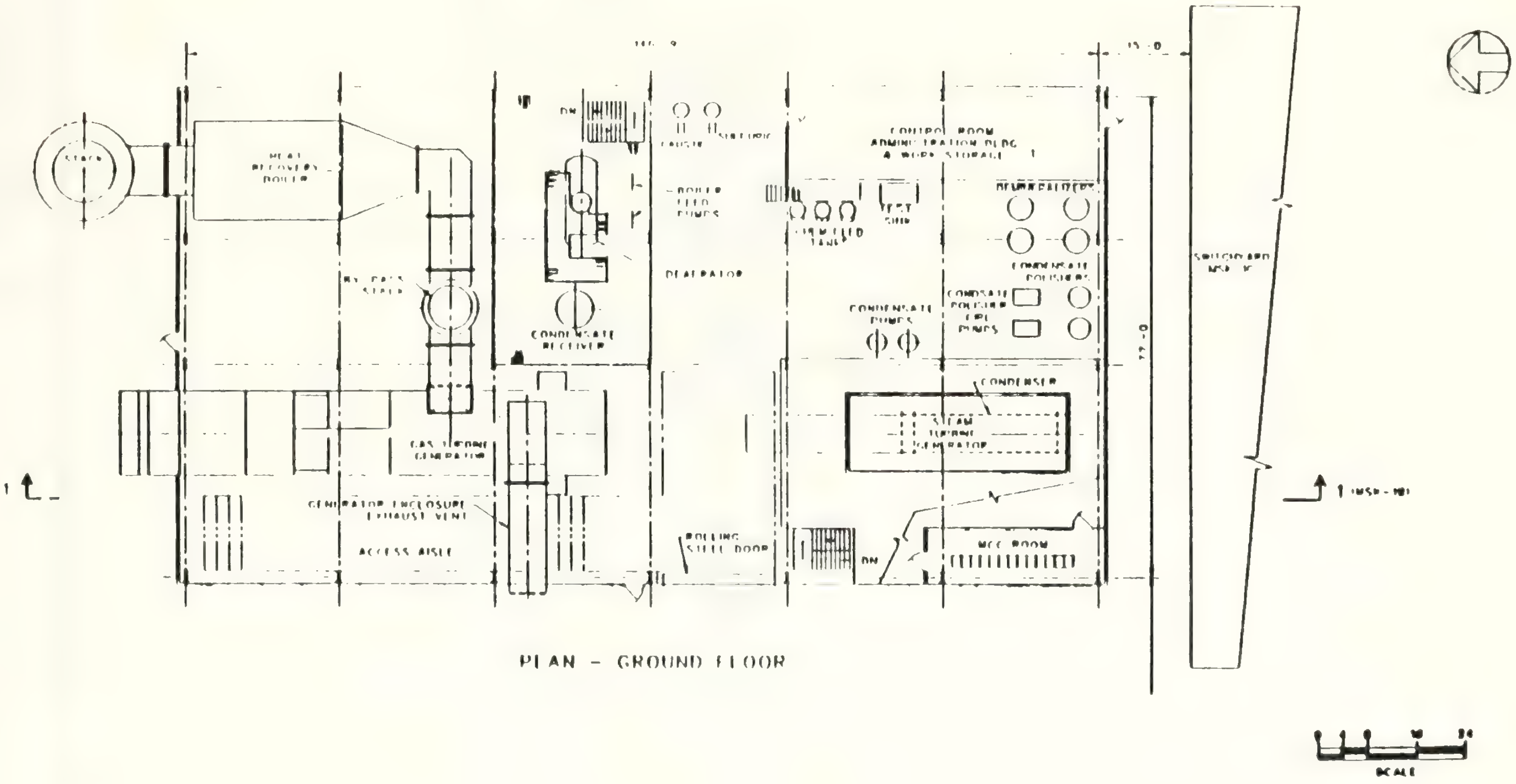
The seasonal heating load, as shown in Table H-2, was calculated to be 52,438 x 10^6 Btu for building heating and 33,697 x 10^6 Btu for tunnel galleries heating, with a heat demand of 15.3 x 10^6 Btu per degree day.

TABLE H-2

**HEAT LOAD PER MONTH
BUILDING AND TUNNELS**

Month	Degree days		Heat load/month (Btu x 10^6)
January	1088		16,634
February	972		14,860
March	846		12,934
April	513		7,843
May	208		3,180
June	36		550
July	0		0
August	9		138
September	60		917
October	316		4,831
November	603		9,219
December	983		15,029
	5,634	Total	86,135

In addition to the building heating load, a heating load for the anaerobic digesters may also exist. The heating load for the digestion process was calculated for the various levels of treatment, which include fast-track improvements in 1988, the addition of Nut Island flows in 1995, and the addition of secondary treatment in 1999. The average monthly heat loads for these milestones are tabulated in Table H-3.



PLAN - GROUND FLOOR

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FIGURE H - 3
POWER HOUSE ARRANGEMENT

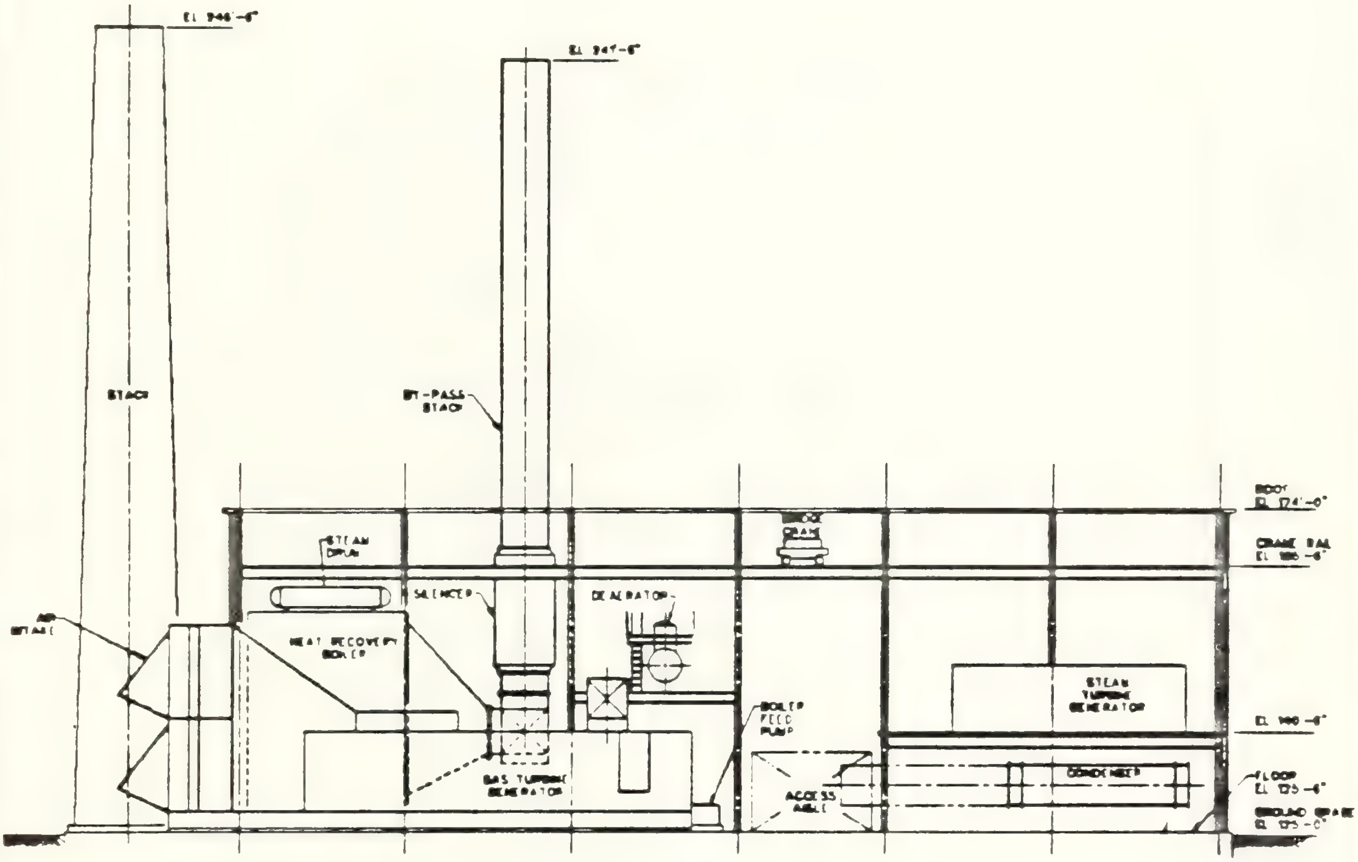

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FIGURE H - 4
POWER HOUSE ELEVATION

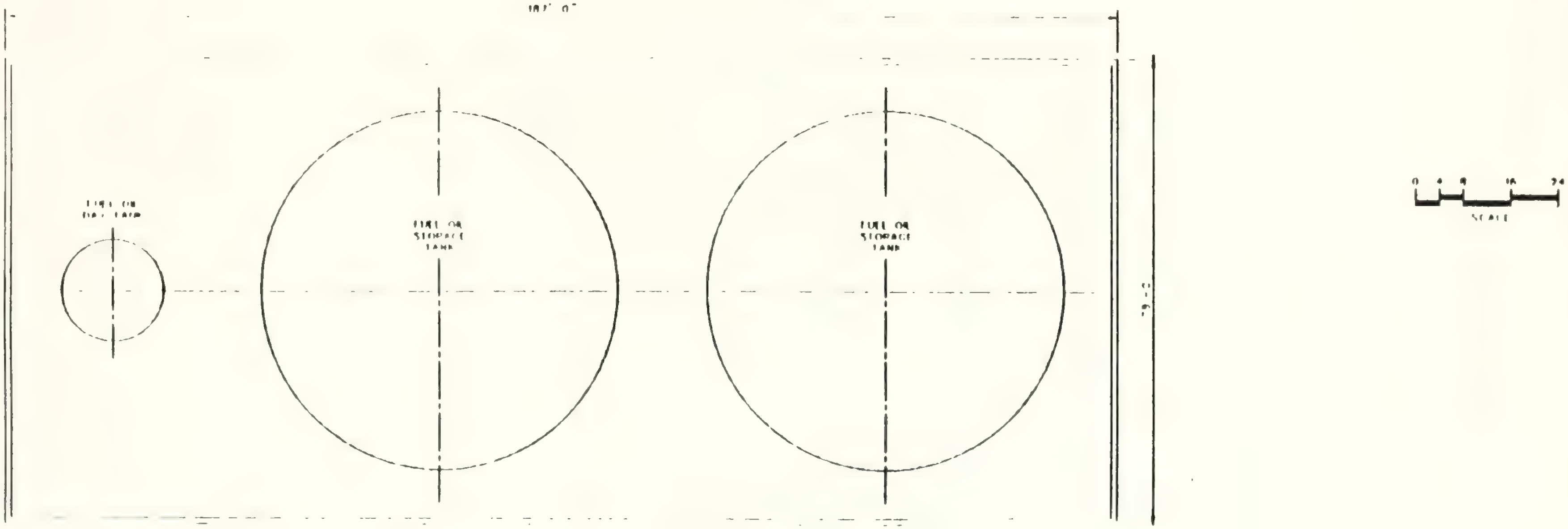

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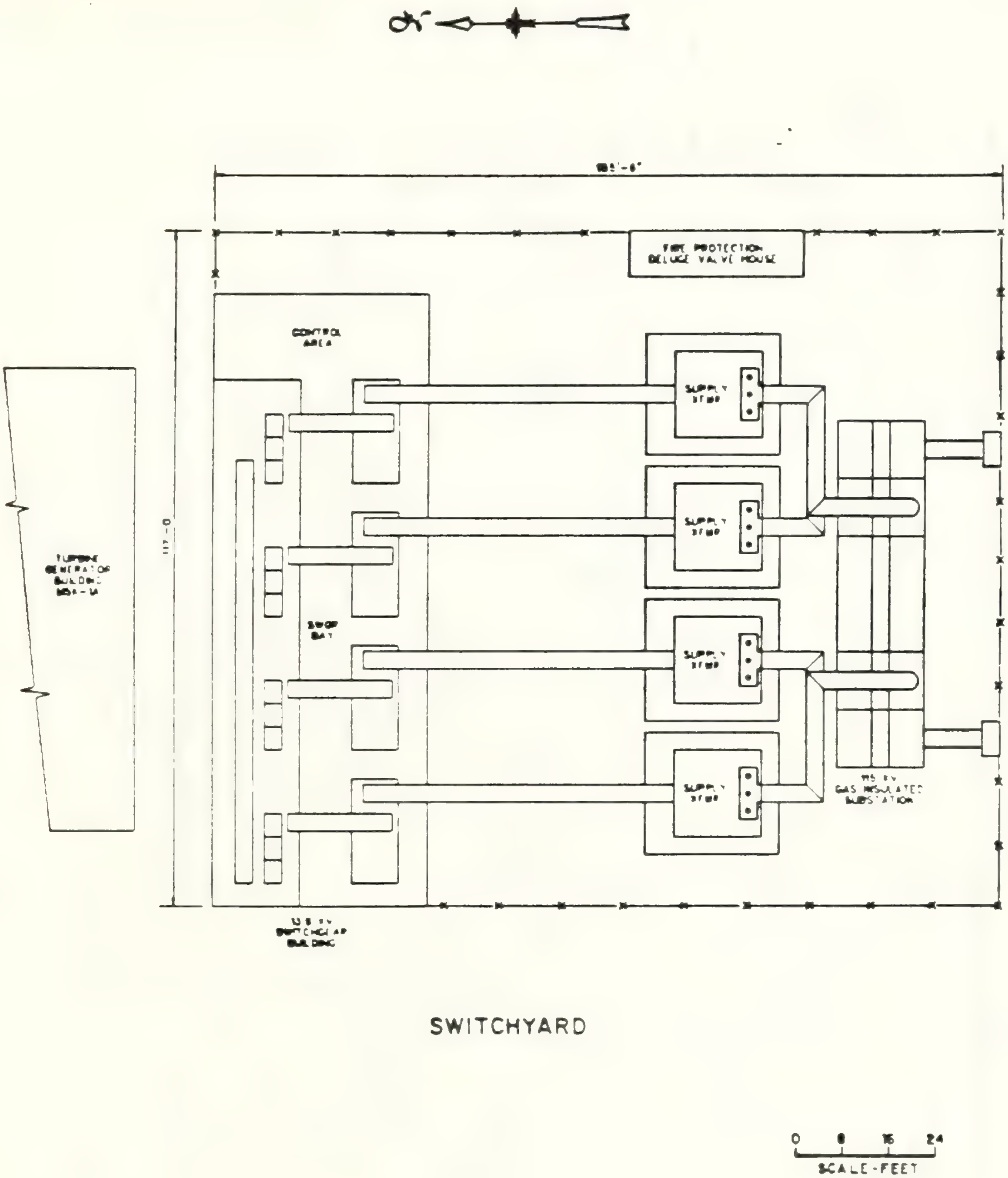
FIGURE H - 5
FUEL OIL STORAGE



SWITCHYARD

MASSACHUSETTS WATER RESOURCES AUTHORITY	FIGURE H - 6 ELECTRICAL SWITCHYARD PLAN

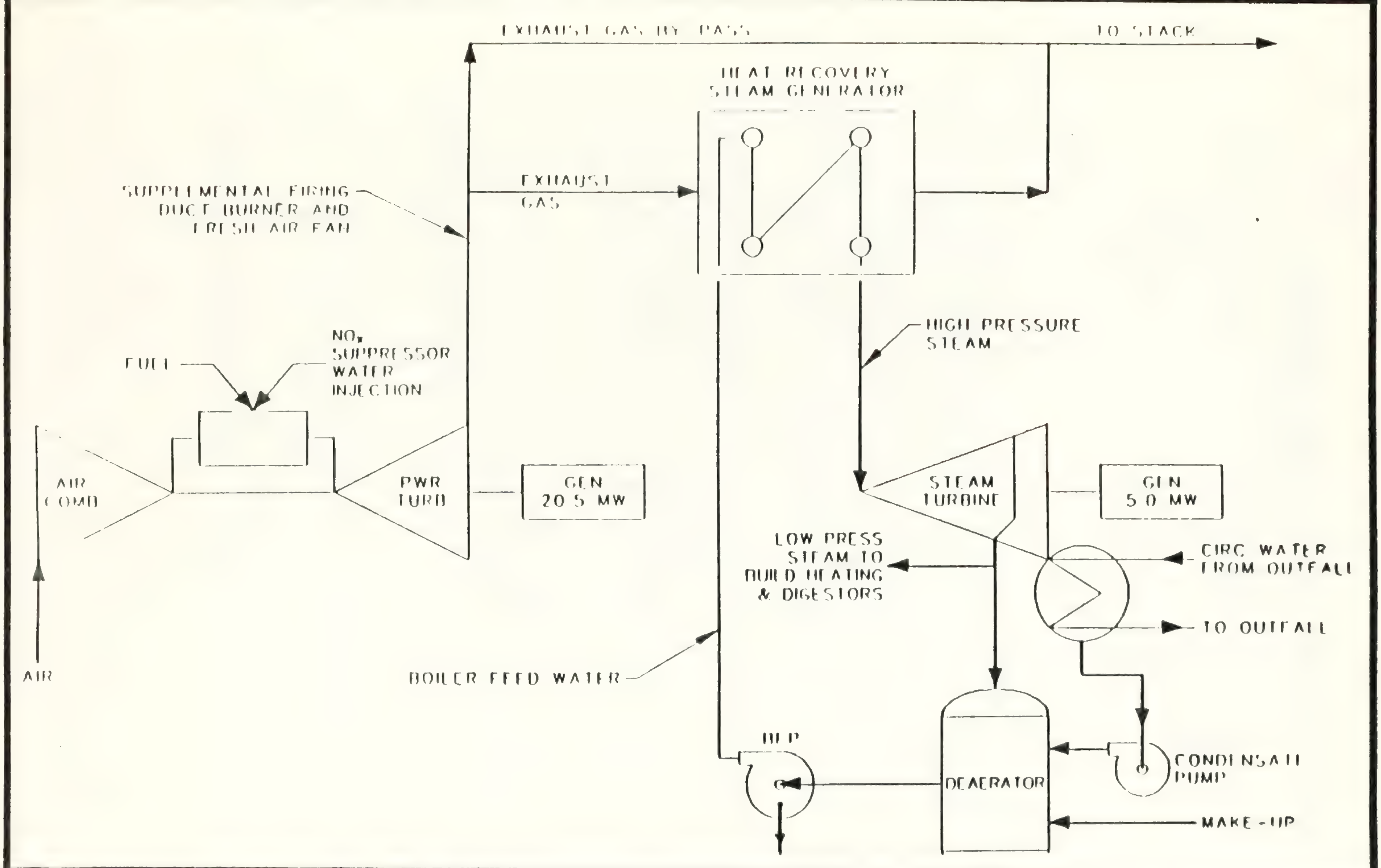


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FIGURE H - 7
FUNDAMENTAL FLOW DIAGRAM

TABLE H-3

PROJECTED AVERAGE MONTHLY DIGESTER HEAT LOADS

Milestone date	Average monthly heat demand Btu/10^6
1988-1994	4,250
1995-1998	11,130
1999-2020	21,000

1.4.1 FUEL

The primary fuel possibilities for the on-site power plant are natural gas and/or No. 2 fuel oil. According to Boston Gas, a new 16-inch-diameter pipeline would have to be constructed from Revere, through Winthrop, to Deer Island. Boston Gas would need to conduct a more detailed study involving gas supply availability and transmission before it could develop a price or commit to sales. Therefore, oil was selected as the primary fuel to use in the economic and environmental analyses of this study. It should be noted that, based on manufacturer's data, air emissions based on oil will generally result in higher emissions than natural gas. Therefore, if natural gas should become an economically viable future alternative, the air quality impacts should be less than those predicted in this report for oil.

The fuel requirements to satisfy required electrical generation and heating demand average 400,000 gal/mo of No. 2 fuel oil. It is currently proposed to deliver fuel by barge. Barges having a capacity of approximately 400,000 gal are available. Barges of this capacity are 165 ft long and 34 ft wide and draw 10 ft when fully loaded. An on-barge unloading capacity of 2,500 gal per hour is available. At this unloading rate seven days would be required to unload the barge. Although the average delivery would be one barge per month, some months may require two deliveries.

Clearly, seven days of unloading time is not acceptable. Therefore, it is proposed that sufficient on-dock unloading capability be provided to reduce the dockside time to 1.7 days. This will entail the provision of an unloading capacity of 10,000 gal/hr. The requirement will be for four 2,500-gal/hr pumps pumping through two 8-in-diameter lines of appropriate material routed in a pipe chase from the dock to the oil storage tanks located adjacent to the existing pumping station.

The fuel storage requirement is for a 30-day reserve storage. This will require two 400,000-gal oil storage tanks in a diked area adjacent to the proposed power plant. These tanks will be 60 ft in diameter by 20 ft high.

The power plant will be totally enclosed in a building 77 ft-0 in. by 146 ft-9 in. by 49 ft-0 in. high, having a stack 121 ft-6 in. high.

1.4.2 ECONOMIC EVALUATIONS

An economic evaluation of the alternatives consisted of comparing the present worth of expenditures for power purchases, fuel purchases, operation, and maintenance of generation capacity, and capital costs for off-site power supplies and new on-site generation capacity over a study period from 1991 to 2020. In each case evaluated, the same electric and building heating loads were met. The evaluations were conducted twice, once with the assumption that digesters would be included in the facility and once with the assumption that they would not.

The digesters require additional heating steam, but they provide a free source of fuel for the committed dual-fuel diesels and/or combined cycle units. Current electric rates and fuel costs were used, without real escalation. A real discount rate of 8.625 percent was used. Results are summarized in Table H-4.

The alternatives evaluated require similar total present worth expenditures, with and without digesters. A lower capital expenditure is obtained with the dual off-site supply and no new on-site generation, but this alternative has the higher operating cost.

A lower operating expenditure is obtained with the single off-site supply and a large (58 MW) combined-cycle power plant, but this alternative requires the highest capital expenditure. A moderate-size (25.7 MW) combined-cycle unit, in conjunction with two off-site supply lines, yields the lowest present worth expenditure, with or without digesters.

A preliminary review of potential air quality impacts using AP-42 emission factors and noise impacts reveals that these concerns are not likely to constrain the implementation of any of the alternatives evaluated based on current regulatory requirements, recognizing that the combined cycle power plant is essentially a peak shaving plant with an annual load factor of 33 percent or less. As discussed below, based on a review of manufacturers' predicted emissions it also appears feasible to operate a 58 MW combined-cycle power plant with an annual load factor of 100 percent. It is possible that any one alternative may require more mitigation controls than those assumed in the analysis, but at this time it is not expected that any such changes would significantly affect the conclusions of this study. It is necessary, however, to define the required control devices and other mitigation measures required to meet applicable limits.

The preliminary worst case assessment of potential air quality impacts from the peak shaving operation of power generation equipment on Deer Island includes a comparison of estimated future impacts with the impacts of existing operations, as well as an assessment of compliance with currently applicable regulatory requirements and air quality standards. The results of this evaluation indicate that air quality would improve relative to existing conditions for all alternatives for the 1995-2020 period, and that current national ambient air quality standards and other regulatory requirements would be met. As presented in Table H-5, there are either no differences or only small differences in annual pollutant concentrations between the alternatives for the various project phases. The decrease in impacts for the 1993-1995 period

TABLE H-4

ECONOMIC EVALUATION OF ALTERNATIVES

	Alternative 1	Alternative 3A	Alternative 3B
	Dual off-site supply, no new generation	Single off-site supply, 58 MW CC *	Dual off-site supply, 25.7 MW CC
WITH DIGESTERS			
Present worth of capital expenditure ($1000)	20,100	60,823	40,423
Present worth of operation expenditures ($1000)	122,480	92,421	99,194
Total present worth ($1000)	142,580	153,245	139,617
WITHOUT DIGESTERS			
Present worth of capital expenditure ($1000)	20,100	60,823	40,423
Present worth of operation expenditures ($1000)	141,396	111,430	117,922
Total present worth ($1000)	161,496	172,254	158,345

* CC = combined cycle

TABLE H-5

CHANGES IN AIR QUALITY ANNUAL CONCENTRATIONS ($\mu g/m^3$) OF ALTERNATIVES 1, 3A AND 3B COMPARED TO EXISTING IMPACTS

	NO_x	SO_2	TSP
Year	Annual	Annual	Annual
Baseline	0	0	0
1988-1989	-7	-1	-1.8
1990-1994	7	+1	0.3
1995-1998	-14	-2	-1.0
Alternative 3A			
Alternative 3B	-14	-2	-2.0
1999-2020			
Alternative 3A	-14	-2	-2.0
Alternative 3B	-12	-2	-2.0

for all alternatives is due to the retirement of the Enterprise diesel generators and the remaining Nordberg diesels.

As discussed above, air quality impacts are based on operation of the combined cycle power plant, for Alternative 3A and 3B, as a peak shaving plant. Based on this study, this is the most economical mode of operation. However, it is possible that in the future it may be desirable to operate the on-site power plant more frequently. On a preliminary screening level of analysis, the emissions from the 25.7 MW (Alternative 3B) and the 58 MW (Alternative 3A) combined cycle power plants, assumed to be operating at full load throughout the year, were calculated using two methods. Based on AP-42, which is a conservative non-vendor specific guideline, this base load mode of operation would not be feasible under present regulatory and ambient air quality conditions for either alternative, for either oil or natural gas firing, unless offset requirements associated with the CO and ozone non-attainment status of Deer Island could be satisfied. Based on manufacturers' predicted emissions, however, this base load mode of operation would be feasible for either alternative for either oil or natural gas firing.

Additional air quality modeling will be performed as part of the final Facilities Plan, once the baseline has been established by DEQE. Refined modeling, incorporating five years of meteorological data and manufacturers' emissions data, will be performed for the 1988-1995 time period. The purose of this refined modeling is to determine equipment operating restrictions, if any, at Deer Island during this period. For the 1995-2020 time period, a screening level analysis, incorporating the DEQE-approved baseline and emissions predicted by manufacturers, will be performed for the combined-cycle power plant alternatives. The purpose of this screening analysis is to determine if there are any air quality imposed restrictions on the size, annual load factor, or fuel burned for an on-island combined cycle power plant. Refined modeling for the 1995 - 2020 time frame will not be required for the Facilities Plan, unless operating restrictions are indicated by the screening analysis.

During detailed design and permitting, refined modeling incorporating five years of meteorological data and vendor specific emissions data should be performed for the 1995-2020 time period.

1.5 RECOMMENDATIONS

Because the present worth cost differences between the three alternatives (with or without digesters) is within ten percent, it is recommended that some additional on-site capacity be installed to protect against total off-site power failure. Based on the economic results of this study, implementation of Alternative 3B (dual 115 kv off-site power cables from BECo and a 25.7 MW combined cycle on-site power plant) is recommended. The combined cycle power plant should be capable of burning No. 2 fuel oil and natural gas. The MWRA should continue to investigate the availability and cost of an off-island source of natural gas.

Based on these preliminary assessments of power demand growth over time, planned modifications/additions, and retirement of existing equipment, the recommended approach for developing the required reliable power supply to support construction and operation of the Deer Island wastewater treatment plant consists of the following steps. These steps are required, based on increased usage with time and the amount of power deemed to be uninterruptible.

1. Install immediate power supply from MECo's Winthrop grid.

2. Install first 115 kv permanent feeder from BECo's K Street substation.

3. Complete installation of 25.7 MW combined cycle power plant.

4. Install second 115 kv permanent feeder from BECo's Chelsea substation.

It is further recommended that MWRA re-evaluate this study prior to authorizing the installation of the combined cycle power plant and the second 115 kv permanent feeder from Chelsea. The results of this study are based on current economics, estimated load projections, and the ability of BECo to provide long-term reliable power from two separate sources. If, in the future, additional on-site capacity is found to be desirable, an evaluation of air quality and noise impacts should be performed.

1.6 IMPLEMENTATION PLAN

It is recommended that MWRA file with BECo immediately a Power Service Agreement requesting electric service to Deer Island. The request should be for two services from separate sources sized at approximately 70 MW. Having two feeders from separate sources satisfies the EPA requirement for an uninterruptible supply. The request for service should include a request for approximately 15-20 MW of immediate power to support construction. The request should specify that the earliest possible in-service date is required to satisfy early site preparation and that a date of no later than 1 January 1990 is acceptable for the immediate power. MWRA should further request that one of the permanent 115-kv cables be installed as soon as possible after the immediate power supply but no later than 1 January 1992.

The request for service must also include a clause that requires BECo to notify MWRA in writing if it cannot have a 115 kv cable in service by 1 January 1992. This notification must include the reasons why this cannot be accomplished and must state the earliest possible in-service date.

For both immediate and permanent power supply options, MWRA will be required to own and operate the low-voltage side of the substation and its own distribution system; BECo is estimating its capital costs only for the high voltage side of the substation. It is recommended that MWRA bidding of its design work immediately begin immediately so that the construction of its substation will be completed in time for the required in-service dates.

In summary, the recommended approach for developing the required reliable power supply to support construction and operation of the Deer Island wastewater treatment plant consists of the following steps:

1. Install immediate power supply from the MECo Winthrop grid by 1 January 1990 or sooner.

2. Install first 115 kv permanent feeder from K Street by 1 January 1992.

3. Evaluate this study to refine the size of the combined cycle power plant. Complete this step prior to authorizing detailed engineering to support steps 4 and 5 below.

4. Complete installation of combined cycle power plant by 1 January 1995 or sooner.

5. Install second 115 kv permanent feeder from Chelsea by 1 January 1995, if required.

Variations not considered in this study, but recommended for future consideration by MWRA during the final power supply detailed engineering and design are:

1. Retention of a private party with specialized expertise in the operation and maintenance of power- and heat-generating systems to operate and maintain all on-site power- and heat-generating equipment.

2. Third-party ownership of the on-site power and steam production facility utilizing some or all of the digester gas.

3. Negotiate a contract, with favorable rates, for an uninterruptible or interruptible (back-up with oil) off-island supply of natural gas.

2.0 INTRODUCTION

The energy requirements of the Deer Island treatment facilities will greatly increase as the existing facilities are rehabilitated or replaced and new facilities are added for wastewater pumping and treatment. As part of the Massachusetts Water Resource Authority (MWRA) Secondary Treatment Facilities Plan, the power and other energy needs of the facilities were identified, and realistic alternative methods for supplying those needs were evaluated. The methodology used required that electrical power and thermal energy requirements, as well as the amount and energy value of digester gas which may be produced by the facility, be estimated. This analysis was necessary to ensure that energy needs are met throughout the rehabilitation, construction, and operation of the Deer Island treatment facilities.

During the preliminary power supply alternatives study, three options were considered. The first was to purchase all energy, primary supply plus backup, from a local utility. The second was to add sufficient generating capacity to meet the entire requirement with the largest unit out of service and therefore have no connection with the local utility. The third involved purchasing all energy from a single source and adding sufficient generating capacity to supply all required energy should the tie with the utility fail in service.

At the time that the Preliminary Energy Report was discussed with the MWRA Board of Directors, the Board voted to eliminate Alternative 2 (i.e., 100 percent on-island generation of Deer Island power requirements). This alternative was, therefore, deleted from further consideration. It was further decided that meetings would be held with both Boston Edison Company (BECo) and Massachusetts Electric Company to determine which could satisfy both the peak demand and EPA's reliability criterion, which requires power from two separate sources. Deer Island is currently within BECo's licensed service area.

Based on the vote of the MWRA Board and the estimated power demands, the following two basic power supply alternatives for primary and backup power for Deer Island were considered further:

	Primary Power	Backup Power
Alternative 1:	Purchase (BECo)	Purchase (BECo) (i.e., a second cable)
Alternative 3:	Combination of on-site generation/purchase	Combination of on-site generation/purchase

3.0 EXISTING POWER GENERATION FACILITIES

3.1 DEER ISLAND DIESEL GENERATORS

The existing power generating capability at Deer Island consists of five diesel generator sets provided by the Enterprise Engine & Machinery Company of Oakland, CA. The diesels are eight-cylinder, in-line type engines that can be operated on digester gas or diesel fuel. The generators are rated at 700 kw each and were furnished by Allis Chalmers. Although they are still fairly reliable after 18 years of service, rehabilitation is taking place under the Fast-Track Improvement's Program.

The Fast-Track Improvements Program calls for the installation in 1988 of two new 6,000-kw, dual-fuel diesel engine/generator sets to be located in a new building adjacent to the existing power plant. The five existing 700-kw diesels will have been rehabilitated, which will extend the life of these diesel engine generators through 1995.

A new power distribution arrangement in 1988 will allow the diesel generators to operate in parallel or to be separated (five existing diesel generators on one bus and two new diesels on another bus). In general, the two new diesels will power the electric-driven raw wastewater pumps, and the existing diesels will power all other plant loads. Breakers will be provided to allow the waste treatment facility to be powered from either of the two new diesels and the five existing diesels.

The existing once-through engine cooling water system will be replaced with a closed-loop system with heat rejection through cooling towers for all diesel engines. The new system will remove heat from the jacket water of the Enterprise engines, the new 6,000-kw diesel engines, and the remaining Nordberg engines.

Sludge-recirculating pumps, sludge heat exchangers, a steam heat exchanger, and an additional Cleaver Brooks boiler will be added to the plant during the Fast-Track Improvements Program. The heated closed-loop cooling water will be routed through heat exchangers to provide heat to the sludge-heating water, which in turn will be routed through heat exchangers to maintain the anaerobic digesters at the proper temperature. This heat-recovery feature has been accounted for in the calculations for the energy supply alternatives.

The two new 6,000-kw diesel engines will be equipped with hospital-type dry silencers for maximum sound attenuation. Waste heat boilers will not be installed for exhaust gas heat recovery.

3.2 DEER ISLAND DIESEL PUMP DRIVES

The Deer Island Main Pumping Station consists of nine vertical-shaft, mixed-flow, bottom-suction sewage pumps. Each pump is rated for 90 million gallons per day (mgd) at 105 ft total dynamic head (tdh) and 400 rpm. The pumps are driven through 90-ft-long shafts. Eight

pumps are driven by diesel engines, and one pump is driven by a 2,000-hp synchronous electric motor with variable-speed magnetic coupling. The coupling is designed to operate over a 250- to 400-rpm speed range.

The diesels are 12-cylinder, radial-type, vertical-shaft engines furnished by the Nordberg Manufacturing Company of Milwaukee and St. Louis. Because of their demonstrated poor reliability, three Nordberg engine-driven pumps will be retired in 1988 under the Fast-Track Improvements Program, and five will remain in service until 1995. New motor-driven pumps will replace the retired units, and one additional motor-driven pump will be added in the currently empty pump bay.

3.3 WINTHROP TERMINAL DIESEL PUMP DRIVES

The Winthrop terminal headworks contains six vertical-shaft, centrifugal-flow, bottom-suction sewage pumps. Four pumps (1 through 4) are driven by electric motors and two pumps (5 and 6) are driven by diesel engines. The electric motor-driven pumps are rated at 15 mgd at 30 ft tdh. The diesel-driven pumps are rated at 60 mgd at 21 ft tdh.

The diesels are six-cylinder in-line engines as manufactured by Fairbanks/Morse, and drive the pumps through 90-degree offset gear boxes.

The Fast-Track Improvements Program calls for the removal of the diesel drives and all associated equipment. They are to be replaced with variable-speed motor drives as part of the Fast-Track Improvements Program.

4.0 ENERGY PROJECTIONS

4.1 PROJECT MILESTONES

The Massachusetts Water Resource Authority (MWRA) improvement program at the Deer Island treatment plant is a phased program that will initially address the reliability and capability of existing treatment facilities, then will address the improvements necessary to achieve both primary and secondary treatment of wastewater at Deer Island. Table H-6 lists the sequence of phases that have the greatest near future impact on power needs.

The Fast-Track-Improvements Program for Deer Island addresses the reliability of the existing facility. Included in the fast-track program is the partial electrification of the influent pumping station. This modification includes the installation of four new electric motor-driven pumps (1,500 kw) capable of pumping 90 mgd of influent. Operation of these pumps requires expanding the electric generation capacity to handle a load of 6,000 kw (4 x 1500 kw/pump). To provide reliability, two 6,000-kw diesel generators (one a standby unit) are scheduled for installation in 1988 along with the new electric motor-driven pumps. Sufficient capacity exists when the Enterprise diesel generators are combined with one new 6,000-kw diesel generator to run five electric-driven pumps.

In addition, two diesel-driven pumps at the Winthrop terminal headworks will be replaced by two new motor-driven pumps (200 kw each). The remainder of the fast-track program involves improvements to and replacement of equipment to permit the Deer Island facility to treat up to the design capacity.

The new primary treatment facilities to be completed in 1995 will have the expanded capacity to treat both the Deer Island and the Nut Island flows. This expansion also includes finalization of the influent and Winthrop terminal pump electrification and new disinfection facilities.

Secondary treatment is scheduled for completion in 1999.

4.2 IMMEDIATE ELECTRIC POWER DEMAND

The immediate power demand consists primarily of construction-related usages which begin prior to construction of the Deer Island permanent power facilities. Tables H-7 and H-8, which identify average and peak power requirements and essential power, respectively, reflect the requirements for operating the treatment facility while constructing two submarine tunnels, one for the South System influent from Nut Island and the other for the Deer Island effluent outfall. The evaluations of the inter-island transport system and the Deer Island effluent outfall are contained in Volumes IV and V, respectively, of the Secondary Treatment Facilities Plan.

TABLE H-6

IMPACT OF PHASES ON POWER NEEDS

Program phase	Function	Scheduled completion
Add two 6000kw diesel generators.* Add electric motor driven pumps at Deer Island and at Winthrop terminal.*	Reliability improvement to existing facility	1989
Remainder of fast-track improvements	Reliability improvement to existing facility	1991
New primary treatment, influent pump electrification, new disinfection, and addition of South System flow	New primary treatment facilities	1995
Provide secondary treatment	Incorporation of secondary treatment facilities	1999

* Already committed under Fast-Track-Improvements Program

TABLE H-7

PRELIMINARY POWER NEEDS OF SECONDARY TREATMENT FACILITIES PLAN TOTAL NEEDS

Year	Description of power needs	Incremental increase to average load (kw) period	Cumulative average load (kw)	Peak load (kw) period	Cumulative peak load (kw)	Cumulative installed capacity (kw)	Cumulative secure capacity* (kw)	Cumulative shortfall (kw)
1986	One electrified influent pump	1,500		1,500		3,500	2,800	
1986	Basic power usage	650	—	650	—	—	—	—
			2,150		2,150	3,500	2,800	0
1988	Electrification of four influent pumps (additional) and Winthrop terminal pumps	2,500	4,650	7,200	9,350	12,000 15,500	6,000 8,800	550
1990	Construction power	10,000	14,650	15,000	24,350	0 15,500	0 8,800	15,550
1991	Primary sludge-dewatering, piers and basic power	4,000	18,650	4,500	28,850	0 15,500	0 8,800	20,050

TABLE H-7
(Continued)

Year	Description of power needs	Incremental increase to average load (kw) period	Cumulative average load (kw)	Peak load (kw) period	Cumulative peak load (kw)	Cumulative installed capacity (kw)	Cumulative secure capacity* (kw)	Cumulative shortfall (kw)
1995	Primary treatment and basic power usage	7,800		9,400				
	Electrification of five influent pumps, Winthrop terminal pumps and South System flows	4,100		17,700		-3,500	-2,800	
	Air emissions control	500		1,250				
	Disinfection (NaOCl purchased)	**		**				
	Construction power	7,000	24,050	-12,000	45,200	12,000	6,000	39,200
1999	Secondary facilities and basic power usage	13,500		19,400				

TABLE H-7 (Continued)

Year	Description of power needs	Incremental increase to average load (kw) period	Cumulative average load (kw)	Peak load (kw) period	Cumulative peak load (kw)	Cumulative installed capacity (kw)	Cumulative secure capacity* (kw)	Cumulative shortfall (kw)
	Additional air emissions control	250		625				
	Sludge processing	2,000		2,000				
	Disinfection (NaOC1 purchased)	**		**				
	Construction power	-3,000		-3,000				
			36,800		64,225	12,000	6,000	58,225

*Secure capacity is that capacity which, because it is provided from two separate sources, is considered to be totally reliable in accordance with EPA criterion as specified in EPA Technical Bulletin EPA-430-99-74-001.

** Included in Basic Power.

TABLE H-8

STFP PRELIMINARY POWER NEEDS: ESSENTIAL POWER* TOTAL NEEDS

Year	Description of power needs	Essential average kw load period	Cumulative essential average kw load	Essential peak kw load period	Cumulative essential peak kw load	Cumulative installed capacity (kw)	Cumulative secure capacity** (kw)	Cumulative essential shortfall (kw)
1986	One electrified influent pump	1.500		1.500		3.500	2.800	
1986	Basic power usage	650	—	650	—	—	—	—
			2.150		2.150	3.500	2.800	0
1988	Electrification of four influent pumps (additional) and Winthrop terminal pumps	2.500	— 4.650	6.400	— 8.550	12.000 15.500	6.000 8.800	— 0
1990	Construction power	10.000	— 14.650	15.000	— 23.550	0 15.500	0 8.800	— 14.750
1991	Primary sludge-dewatering, piers and basic power	1.000	— 15.650	1.500	— 25.050	0 15.500	0 8.800	— 16.250

*Essential power is that power required to operate those plant operations which, if interrupted, would result in unacceptable discharges and or could present danger to personnel health and safety.

**Secure capacity is that capacity which, because it is provided from two separate sources, is considered to be totally reliable in accordance with EPA criterion as specified in EPA Technical Bulletin EPA-430-99-74-001.

TABLE H-8

STFP PRELIMINARY POWER NEEDS: ESSENTIAL POWER*
TOTAL NEEDS
(Continued)

Year	Description of power needs	Essential average kw load period	Cumulative essential average kw load	Essential peak kw load period	Cumulative essential peak kw load	Cumulative installed capacity (kw)	Cumulative secure capacity** (kw)	Cumulative essential shortfall (kw)
1995	Primary treatment and basic power usage	7,800		9,400				
	Electrification of five influent pumps, Winthrop terminal pumps and South System flows	4,100		17,700		(3,500)	(2,800)	
	Air emissions control	500		1,250				
	Disinfection (NaOCl purchased)	0		0				
	Construction power	-7,000		-12,000				
			21,050		41,400	12,000	6,000	35,400

*Essential power is that power required to operate those plant operations which, if interrupted, would result in unacceptable discharges and/or could present danger to personnel health and safety.

**Secure capacity is that capacity which, because it is provided from two separate sources, is considered to be totally reliable in accordance with EPA criterion as specified in EPA Technical Bulletin EPA-430-99-74-001.

TABLE H-8

STFP PRELIMINARY POWER NEEDS: ESSENTIAL POWER*
TOTAL NEEDS
(Continued)

Year	Description of power needs	Essential average kw load period	Cumulative essential average kw load	Essential peak kw load period	Cumulative essential peak kw load	Cumulative installed capacity (kw)	Cumulative secure capacity** (kw)	Cumulative essential shortfall (kw)
1999	Secondary facilities and basic power usage	6,000		6,000				
	Additional air emissions control	250		625				
	Sludge processing	0		0				
	Disinfection (NaOC1 purchased)	***		***				
	Construction power	-3,000	24,300	-3,000	45,025	12,000	6,000	39,025

*Essential power is that power required to operate those plant operations which, if interrupted, would result in unacceptable discharges and/or could present danger to personnel health and safety.

**Secure capacity is that capacity which, because it is provided from two separate sources, is considered to be totally reliable in accordance with EPA criterion as specified in EPA Technical Bulletin EPA-430-99-74-001.

***Included in Basic Power.

The construction power required by the machines used to bore the tunnels averages 7,000 kw for the larger outfall tunnel that will carry the Deer Island effluent, and 5,000 kw for the smaller inter-island transport tunnel that will carry the South System flow from Nut Island to Deer Island. An additional 3,000 kw of construction power is assumed for miscellaneous construction equipment and facilities.

The average construction power demand (10,000 kw) does not allow for the two tunnels to be constructed simultaneously. The peak construction power demand (15,000 kw) accounts for the eventuality that they will be constructed simultaneously.

When the tunnel construction is completed in 1995, the associated construction power requirement will be eliminated. The remaining 3,000 kw of construction power will support continuing construction of the secondary wastewater treatment and power generation facilities scheduled to be completed in 1999.

4.3 PERMANENT ELECTRIC POWER DEMAND

The expanded treatment facilities at the Deer Island wastewater treatment plant will require increased power. The increase in energy requirements will take place in a stepped fashion as the quantity of wastewater treated is increased, and the degree of treatment improves.

The preliminary electric power requirements were tabulated by calculating the equivalent electric power requirements for 1986 and adding the stepped increases for the various uses identified by the process engineers, as discussed in Volume III of the Deer Island Secondary Treatment Facilities Plan. Tables H-7 and H-8 respectively, list electrical power requirements for total power and essential power only..

The total electric power requirements for the MWRA Deer Island wastewater treatment facility will increase from an average load of 4.65 MW in 1988 to an average load of 36.80 MW and a peak load of 64.22 MW in 1999.

To determine the required electrical and equivalent electrical loads for the facility, a load-duration curve was developed (see Figure H-1, page H-6). The load duration curve was based on data obtained from the MWRA regarding the number of pumps in service and the appropriate numbers of hours of operation per year for the various combinations of pumps. Those data are presented in Tables H-9 and H-10 along with a tabulation of annual power requirements based on current pumping needs. This was done in order to determine the most economic mix of purchased plus self-generated power.

These electric demand data were presented to BECo in a letter dated 19 May 1987. The data were further discussed at a meeting on 5 June 1987 to solicit BECo's assistance in determining capital, energy, and capacity charges for providing all the electric power that will be required by MWRA's Deer Island secondary wastewater treatment plant. These data were similar to those provided to BECo on a preliminary basis in 1986.

TABLE H-9

DEER ISLAND CURRENT SERVICE PUMP DURATIONS FOR BASE LOAD DURATION CURVE

Number of pumps/ capacity (mgd)	Percentage of time	Annual hours of operation
Two/180	100	8760
Three/270	99.9	8750
Four/360	95	8320
Five/450	75	6570
Six/540	2	170
Seven/630	0.1	10
Eight/720	0.05	5
Nine/810	0.01	1

TABLE H-10

YEARLY kw HOUR DEMAND, 1986

Incremental	Load kw	hr/yr	kwh/hr
Minimum load*	4,500	8,760	39,420,000
+ third pump	1,500	8,750	13,125,000
+ fourth pump	1,500	8,320	12,480,000
+ fifth pump	1,500	6,570	9,855,000
+ sixth pump	1,500	170	255,000
+ seventh pump	1,500	10	15,000
+ eighth pump	1,500	5	7,500
+ ninth pump	1,500	1	1,500
Total			75,159,000

*Minimum load equals two influent pumps (3,000 kw) + house load (1,500 kw). The house load was determined from an actual measurement taken at the Deer Island facility.

4.4 HEATING DEMAND

The heating demand at the MWRA Deer Island wastewater treatment plant will increase as new facilities are constructed to provide improved wastewater treatment for increased volumes of wastewater. The heating load varies annually in accordance with the number of degree days/month. The average was varied in a stepped fashion to accommodate increases in flows and implementation of secondary treatment.

Total seasonal heating loads were determined by using published data that give seasonal steam demand per degree day per 1,000 ft^3 to be heated for the various types of buildings. This reflects hours per day of occupancy and required comfort levels. A value of 1,000 Btu/lb of useful heat is assigned to a pound of steam. For the buildings, a value of 0.962 lb steam/degree day/1,000 ft^3 was used. For the tunnel galleries, a value of 0.202 lb steam/degree day/1,000 ft^3 was used. This preliminary heating load estimate was based on an ultimate building volume of approximately 8,000,000 ft^3 and tunnel gallery volume of approximately 9,000,000 ft^3.

The number of degree days per month and the total degree days per heating season for Boston were obtained from the 1981 edition of the ASHRAE Fundamentals Handbook. They are shown in Table H-11, which also shows expected monthly heat loads.

In addition to the building heating load, a heating load for the anaerobic digesters may also exist. The heating load for the digestion process was calculated for the various levels of treatment, which include fast-track improvements in 1988, the addition of Nut Island flows in 1995, and the addition of secondary treatment in 1999. The average monthly heat loads for these milestones are tabulated in Table H-12.

4.5 DIGESTER GAS PRODUCTION

The anaerobic digestion process produces digester gas as a product while significantly reducing the weight of sludge requiring disposal. The digester gas produced consists primarily of methane, some carbon dioxide, and hydrogen sulfide. The heating value of the gas is estimated to be 600 to 650 Btu/scf. The amount of gas produced depends on the amount of volatile solids removed from the influent and the digester reduction efficiency.

The digester gas production was calculated for the various stepped improvements in treatment from 1988 to 1999 and is presented in Table H-13. The economics of using digester gas, if available, are discussed in Chapter 6.0.

TABLE H-11

HEAT LOAD PER MONTH
BUILDING AND TUNNELS

Month	Degree days	Heat load/month ($Btu \times 10^6$)
January	1088	16.634
February	972	14.860
March	846	12.934
April	513	7.843
May	208	3.180
June	36	550
July	0	0
August	9	138
September	60	917
October	316	4.831
November	603	9.219
December	983	15.029
TOTAL	5634	86.135

The seasonal heating load was calculated to be 52.438×10^6 Btu for building heating and 33.697×10^6 Btu for tunnel galleries. This results in a total seasonal heating load of 86.135×10^6 Btu and a heat demand of 15.3×10^6 Btu per degree day.

TABLE H-12

PROJECTED AVERAGE MONTHLY DIGESTER HEAT LOADS

Milestone date	Average monthly heat demand $Btu/10^6$
1988-1994	4.250
1995-1998	11.130
1999-2020	21.000

TABLE H-13

DIGESTER GAS PARAMETERS*

	Period		
	1986 to 1994	1995 to 1998	1999 to 2020
Sludge production (dry tons/day)			
Primary sludge production	58	163	177
Secondary sludge production	0	0	113
Total sludge production (solids)	58	163	290
Gas production			
Total Gas, Mcf/day	0.744	2.01	3.84
MBtu/day	446	1,254	2,304
MBtu/hr	18.6	52.26	96

The amount of digester gas produced is based on data provided by Black & Veatch in conjunction with Camp Dresser & McKee.

5.0 ALTERNATIVE 1: OFF-SITE PURCHASE OF ALL REQUIRED ADDITIONAL ENERGY

Alternative 1 consists of purchasing all the additional electric power required for the Deer Island treatment facility from Boston Edision Company (BECo). Because of the load size, BECo proposes to bring electric power to Deer Island at 115 kv, terminating at an on-island 115-kv switch yard. No additional on-site generating capacity beyond the two committed 6 MW dual fuel diesels is proposed.

5.1 RELIABILITY CONSIDERATIONS

Based on EPA regulations, a major portion of the electric power required at Deer Island falls into the critical service category and is therefore uninterruptible or essential as identified in Tables H-7 and H-8 respectively. BECo was informed of this requirement in a meeting on June 5, 1987. BECo responded that the requirement could be satisfied by bringing 115-kv cables capable of delivering 70 MW of power (normal supply) from the K street substation to Deer Island (submarine) and from BECo's station #488, Chelsea, to Deer Island via East Boston and across Logan Airport (buried and submarine). With these two cables in place from separate sources, the EPA reliability criterion is satisfied.

5.2 SCHEDULE TO PROVIDE ELECTRIC SERVICE

BECo has stated that with authorization as early as September 1987 they would envision a schedule for delivering the 115-kv electric service to Deer Island extending to mid-1991. The major activities that make up the project effort are the permitting activities and the engineering, fabrication, and construction of the cable trenches, cable and the switchyard. BECo's schedule is driven by the work load to which their staff is currently committed.

BECo did state in a meeting on June 5, 1987 that if certain activities could be performed by others, it might be possible to meet a required in-service date of January 1, 1990 to support construction of underharbor tunnels.

A schedule has been developed (Figure H-8) that, if adhered to, would permit BECo to deliver the 115-kv electric service from BECo's K Street substation by January 1, 1990. This schedule is contingent on completion of the permitting activities in ten months, which should be achievable. In addition, this schedule requires a commitment by BECo to perform engineering, procurement, and some fabrication simultaneously with the permitting activities and prior to permit receipt.

BECo has since negotiated with Massachusetts Electric Company (MECo) to supply the required 15-20 Mw of construction power. This source of supply will remain in service until the permanent power supplies are in place. The power will be delivered to BECo at 24 kv at the Winthrop/Boston line. MECo has assured BECo that meeting the required in-service date of January 1, 1990 is easily achievable since only 18 months is required to complete the installation. It is estimated that the cost for this service could be approximately $2.5 million dollars. If this service could be routed in the same trench as the proposed new water

main, savings of approximately $500,000 could be achieved.

This supply will be delivered via an underground transmission line originating from a substation in Winthrop. It is currently proposed that this service will terminate at a 24-kv to 13.8-kv temporary transformer owned by BECo to be located at the on-site electrical substation (see Volume III, Figure 11.1.3-1). MWRA will be responsible for the distribution system required to deliver the construction power where it is needed.

5.3 CAPITAL COST FOR PROVIDING ELECTRIC SERVICE

The costs for the various permanent power supply routes to Deer Island are outlined as follows (for all cost estimates, the most direct routes are assumed; for the trenching estimates, it is assumed that no serious problems will be encountered, such as ledge or bedrock):

1. Submarine cables from K Street to Deer Island

   Distance: 20,500 ft

   Construction: Four 400-KCmil copper single-phase submarine cables ($32/ft) in one trench (10 ft deep in ship channels and 5 ft deep in other areas)

   Cost in 1987 dollars: $8,900,000

   Cost of one 115-kv circuit breaker at K Street: $225,000

2. Buried and submarine cables from station #448, Chelsea to Deer Island via East Boston and across Logan Airport

   Distance: 10,500 ft

   Construction: Four 400-KCmil copper single-phase buried and submarine cables for entire length in one trench

   Cost in 1987 dollars: $10,000,000

   Cost for one 115-kv circuit breaker at station #448: $225,000

3. Two separate submarine cables from K Street to Deer Island with eight single-phase cables in one trench (no service from Chelsea)

   Cost in 1987 dollars: $12,500,000

   Cost of two 115-kv circuit breakers at K Street: $450,000

Extra cost for two trenches: $2,750,000

Note: Option 3 does not comply with the EPA requirement of having two separate sources of supply in order to be considered uninterruptible. For that reason, it should not be considered further.

BECo's policies which will affect their evaluation of the preceding costs are:

1. BECo will provide one source of supply in the public way at BECo expense, not to exceed 1.5 times the annual estimated revenue. An executed agreement between MWRA and BECo to that effect would be required.

2. Said agreement would also require payment for all additional work over the normal supply. Normal supply is four 400-KCmil copper single-phase cables in a single trench from the K Street substation. The capital costs would be:

$8,900,000	for cable trenching
225,000	for circuit breaker at K street
$9,125,000	total

BECo would, thus, require a $6,085,000 annual revenue to support this $9 million investment. If this return is not achievable, that portion of the capital cost that could not be recovered in 18 months would be passed on to MWRA.

Based on BECo's requirements for capital investment, the annual revenue of $6,085,000 to support its capital investment in a 115-kv cable from K Street will not be achieved until 1995. Therefore, negotiations with BECo will be required to determine if an in-service date prior to 1995 for this 115-kv cable will result in additional capital charges to MWRA.

When performing the economic evaluation of this alternative, the capital costs of approximately $4,500,000 for construction of the MWRA-owned substation and maintenance costs were not included since the substation is common to all supply alternatives.

6.0 ALTERNATIVE 3: COMBINED ON-SITE GENERATION AND OFF-SITE PURCHASE

Alternative 3 consists of purchasing primary electric power from BECo and providing electric power from additional on-site generation. Primary electric power can be delivered to Deer Island either by submarine cable from K Street or by buried and submarine cable from Chelsea via East Boston and across Logan Airport, as discussed in Section 5.0. Primary electric power would be delivered at 115 kv to the MWRA-owned switchyard.

For the single cable off-site supply option, backup electric power would be self-generated by a combined-cycle plant, capable of generating up to 58 MW plus two 6-MW diesel generators, for a total capacity of 70 MW. The combined-cycle plant would consist of two combustion turbine-generators (rated at 20 MW each when ambient temperature is 88° F conditions) exhausting to two heat-recovery steam generators (HRSG), which, combined, produce sufficient steam to generate 18 MW in a single steam turbine-generator. The HRSGs would be supplementary-fired to utilize the complete combustion capacity of the exhaust gas.

An auxiliary boiler would provide backup to meet essential power demand in case one of the two trains that make up the combined-cycle plant is not operable to back up the primary electric power supply from BECo. The auxiliary boiler would produce sufficient steam to generate an additional 10 MW in the steam turbine-generator. The auxiliary boiler would also be capable of supplying full steam requirements for heating demand.

The potential on-site generating capacity is tabulated in Table H-14. It shows the methodology of the power generation facilities to meet both peak power demand and essential power demand, assuming the unavailability of any single power generating component.

6.1 RELIABILITY CONSIDERATIONS

The EPA requires two independent sources of electric power at full capacity to ensure reliability of operation of waste treatment facilities. To satisfy this requirement, the on-site power generation facilities, comprised of the 58-MW combined-cycle power plant, the auxiliary boiler, and the two diesel generators, would provide 100-percent backup capability to the primary power supply from BECo. In addition, the on-site power generation facilities would be capable of supplying essential peak electric power demand (as shown in Table H-8) in case the largest component of the power generation facility is out of service coincident with an interruption of primary service from BECo.

Additional reliability is provided through the design process by specifying high quality equipment from experienced and prequalified suppliers and by providing redundancy of equipment where justified.

6.2 ECONOMIC SELF-GENERATION CAPACITY

The digester gas produced in the waste treatment process can be used as fuel in the combustion turbines. The electricity generated can be used to shave the quantity of purchased electricity during peak price periods, which are 10^{6} hours per day Monday through Friday.

TABLE H-14

ON-SITE GENERATING CAPACITY

	Capacity (kW)		
	Each	All Facilities Available	Single Largest Component Unavailable*
Combustion turbine-generators (2)	20,000	40,000	20,000
Steam turbine generators (2)			
Steam from HRSG (2)	9,000	18,000	9,000
Steam from auxiliary boiler	10,000	**	10,000
Diesel generators (2)	6,000	12,000	12,000
Total		70,000**	51,000

* Unavailability of a single component (e.g., the combustion turbine/generator or HRSG) would result in isolation of one train of the combined cycle plant.

** Normal operation to satisfy peak demand would not require the auxiliary boiler, which is provided as backup.

Since digester gas is produced continuously, it would have to be stored during off-peak hours for consumption during peak hours. A storage capacity of 16 hours is sufficient. It is assumed that digester gas would be burned as produced on weekends, since weekends are offpeak hours.

Digester gas production increases to 2,304 x 10^6 Btu/day in 1999 (see Table H-13). Consumption of this gas during the 10-hour peak period results in 230 x 10^6 Btu/hr. The combustion turbines can generate approximately 27 MW burning the digester gas, which translates into a daily reduction in electricity purchase of 270,000 kw-hr.

Burning digester gas represents the most economical self-generation capacity, because if the gas is available it has no cost. Related costs do apply, however, including cost of equipment required to store and transfer the gas, cost of operating personnel, and maintenance costs.

6.3 CAPITAL COST OF CAPACITY

The preliminary capital cost estimate of the on-site generation facilities is based on vendor quotes for a combined-cycle plant and an interconnected auxiliary boiler. These costs are presented in Table H-15. The diesel generators will be added as part of the Fast-Track Improvements Program and are not included in the cost estimate.

The cost estimate assumes a combustion turbine as the basis for sizing and selecting components for the combined-cycle plant.

Budgetary prices were solicited from Stewart & Stevenson Services, Inc., and Solar Turbines, Inc. The capital cost estimate is based on this input combined with Stone & Webster's in-house cost-estimating data and experience.

An option evaluated under the partial self-generation alternative was a reduced-size combined-cycle plant plus two off-site feeders. This plant was sized to provide the most cost-effective mix of off-site purchase and self-generated power.

Combined-cycle plants having a capacity of 25,700 kw and 15,000 kw were considered. Budgetary prices were obtained from the vendors who had supplied pricing for the 58,000 kw plant. These capital cost estimates are also presented in Table H-15. It was determined that a combined-cycle unit having a capacity of 25,700 kw at ambient temperature conditions of 88° F is the most economical choice.

6.4 OPERATING AND MAINTENANCE COST OF CAPACITY

The operating and maintenance cost for the on-site generation facilities comprises variable costs for fuel, maintenance equipment, spare parts, and fixed costs for operating and maintenance personnel.

TABLE H-15

PRELIMINARY CAPITAL COST ESTIMATE FOR ON-SITE GENERATING CAPACITY

	58 MW ($ x 10^6)	25.7 MW ($ x 10^6)	15 MW ($ x 10^6)
Plant direct costs (including auxiliaries, foundations, buildings)			
Combustion turbine-generators	18.7	8.2	5.1
Heat recovery steam generators	6.3	3.0	1.4
Steam turbine-generator	7.8	3.0	1.4
Heat rejection system	1.0	0.5	0.6
Auxiliary boiler	0.5		
Miscellaneous	1.7	0.8	0.7
Subtotal direct costs	36.0	15.5	9.2
Indirect costs (including contingencies, allowance for funds used during construction, engineering, and construction management)	18.0	7.8	4.6
Total installed cost, 1987 Dollars	54.0	23.3	13.8

The price of distillate fuel used as the basis for the economic evaluation in Chapter 7.0 is $\$3.75/10^6$ Btu, or 52¢ per gallon. The actual fuel price at the time of operation, of course, will vary with market conditions. Based on the price, the fuel cost for the combined-cycle plant would be $0.035/kwh of generation. The most economic dispatching scenario for the on-site generating capacity will determine the annual fuel cost. This is discussed in Section 7.0.

The remaining operating and maintenance costs, excluding fuel, can be estimated at $40/kw-yr for these sizes of combined-cycle plants. This results in an annual cost of $2,500,000 and $1,030,000, respectively, which is used as part of the economic evaluation in Section 7.0.

7.0 ECONOMIC EVALUATION OF POWER SUPPLY ALTERNATIVES

7.1 INTRODUCTION

The objective of this section is to evaluate alternative strategies to meet the electric power demands of the Deer Island facility. An earlier study entitled "Preliminary Screening of Energy Supply Alternatives" concluded that a combination of on-site and off-site power sources is the appropriate approach. This evaluation looks at that approach in greater detail to determine the optimal number of independent off-site supplies and the optimal amount of on-site generation.

The two major alternatives presented in the preceding chapters and several variations were evaluated in terms of life-cycle present worth cost. Alternative 1, reflecting a strategy of purchasing most primary and all backup power from an electric utility (e.g., BECo), requires the installation of two independent off-site supplies, but no additional on-site generating capacity beyond the two committed 6-MW dual-fuel diesels.

Alternative 3 reflects a strategy of optimizing the mix of off-site and on-site power sources to minimize life-cycle cost. Options evaluated within this alternative included:

3A: A single off-site source and a two-unit combined cycle plant

3B: Two off-site sources and a single unit combined cycle plant.

Option 3B was evaluated with several different schedules for installation of the second off-site supply and the combined cycle unit.

Economic evaluations consisted of comparing the present worth of expenditures for power purchases, fuel purchases, operation and maintenance of generation capacity, and capital costs for off-site power supplies and new on-site generation capacity over a study period from 1991 to 2020. In each case evaluated, the same electric loads were met, as were the building heating loads. The evaluations were conducted twice, once assuming that digesters would be included in the facility, once assuming that they would not. The digesters require additional heating steam, but they provide a "free" source of fuel for the committed dual-fuel diesels and/or for combined-cycle units. Present electric rates and fuel costs were used, without real escalation. A real discount rate of 8.625 percent was used. Results are summarized in Table H-16.

7.2 ASSUMPTIONS

To perform an economic evaluation, it is necessary to make several assumptions regarding prices, electric rates, and acceptable financial performance. This subsection documents those assumptions.

TABLE H-16

ECONOMIC EVALUATION OF ALTERNATIVES

	Alternative 1	Alternative 3A	Alternative 3B
	Dual off-site supply, no new generation	Single off-site supply, 58 MW CC*	Dual off-site supply, 25.7 MW CC
WITH DIGESTERS			
Present worth of capital expenditure ($1000)	20,100	60,823	40,423
Present worth of operation expenditures ($1000)	122,480	92,421	99,194
Total present worth ($1000)	142,580	153,244	139,617
WITHOUT DIGESTERS			
Present worth of capital expenditure ($1000)	20,100	60,823	40,423
Present worth of operation expenditures ($1000)	141,396	111,430	117,922
Total present worth ($1000)	161,496	172,253	158,345

* CC = combined cycle

7.2.1 ELECTRIC RATES

Power would be purchased from BECo at 115 kv under a rate similar to General Services Rate G-3, which is summarized in Table H-17. The G-3 rate is based on 13.8-kv service. It was assumed that the electric rates would remain stable in constant dollar terms (that is, they will increase at roughly the same rate as other prices in general).

7.2.2 FUEL

The price of #2 distillate oil (diesel fuel) delivered to Deer Island is roughly 52¢/gal, or \$3.75/MBtu. Fuel costs are also assumed to remain stable in real terms. The price of natural gas, if it were available, would be about the same in the current market. Boston Gas has determined that it would have to assess a capital charge of \$5,000,000 to provide adequate gas service for a combined-cycle power plant on Deer Island. Boston Gas has not committed sufficient reserves to meet such a demand year-round. For this reason, it is assumed for the purposes of this study that all fuel (other than digester gas) used at the facility will be distillate oil. However, MWRA should continue to investigate the availability and cost of natural gas.

7.2.3 ECONOMIC CRITERIA

Economic comparisons are based on the present worth of future expenditures (life-cycle costs) from 1991 to 2020 measured in 1987 constant dollars and discounted at a real rate of 8.625 percent per year, in accordance with guidelines established for the project. It is assumed that the 8.625 percent represents weighted cost of capital for MWRA and that an incremental investment will be attractive to MWRA if it has an internal rate of return in excess of that value.

7.3 EVALUATION OF ALTERNATIVES

This subsection describes the process of selecting and evaluating alternative power supply strategies.

7.3.1 EVALUATION MODEL

A spreadsheet model was developed to simulate the operation of various power supply strategy alternatives over the 30-year study period and to calculate the present worth of expenditures for capital and operational costs.

The first section of the model consists of assumptions and data common to all alternatives in a comparison: discount rate, base years for prices and present worth, fuel prices, electric rates, general descriptions of generating units, a non-dimensional electric load duration curve, forecast peak electric loads for each group of years, forecast heating loads and digester gas quantities, and retirement schedules for existing and committed capacity. This section also contains intermediate calculations of items such as period present worth factors

TABLE H-17

BECO PURCHASE POWER RATES

Demand charge(a)

November-June:	\$6.74/kw-mo.
July-October:	\$15.76/kw-mo.

Energy Charge(a)

	Onpeak hrs	Offpeak hrs(b)
November-June:	2.912¢/kWH	0.703¢/kwh
July-October:	3.046¢/kWH	0.472¢/kwh

Fuel adjustment charge(c): 2.047¢/kWH

NOTES:

(a) Taken from the Boston Edison Company's General Service Rate G-3, effective 16 July 1986.

(b) On-peak hours: 8 a.m. - 9 p.m. EST, 9 a.m. - 10 p.m. EDT, weekdays.
Off-peak hours: all other hours

(c) Provided by Peter Moloney of BECo over telephone on 24 September 1986; applicable from August through October of 1986.

and minimum required capacity. Table A-1 in the Attachment is a printout of this section of the spreadsheet.

The next section of the spreadsheet consists of input describing a particular strategy alternative and the resulting capital expenditures, energy balances, annual costs, and total present worth of costs. Table A-2 in the Attachment is a sample printout of such a section. A final section consists of working tables used to dispatch load to available power sources during each time period.

The total present worth cost is the sum of the present worth of capital expenditures and the present worth of operating expenditures. Peak and off-peak purchased energy are calculated through a dispatch algorithm that uses the load duration curve and allocates horizontal bands of its area (total energy) to supply sources as the basis of incremental cost and capacity (adjusted for availability). When digester gas is available, the energy it can produce in the committed 6-MW diesels and any new combined-cycle capacity is dispatched first at zero cost. After that, the incremental cost of power from the engines and combined-cycle units burning distillate oil is compared with the peak or off-peak purchase rate plus fuel adjustment charge to determine if on-site capacity should be operated or left in reserve. On-site generation is adjusted for extraction steam where appropriate. Off-site purchases fill in any energy requirements not met by the on-site capacity.

Fuel consumption and annual expense are determined based on the operation of each on-site generating source and on the amount of heating load that cannot be met by means of cogeneration. Operation and maintenance expense is based on installed on-site generation capacity.

7.3.2 SINGLE OFF-SITE SUPPLY OPTIONS

An additional power source, beyond existing and committed on-site generation and MECo capacity, will be required at Deer Island by the beginning of 1992. At that time, peak loads are forecast at 28.85 MW (plus 6-MW for engine-driven pumps), while capacity adjusted for outage of the largest unit (N-1 capacity) would be 9.5 MW. (Critical load at that time would be 25.05 MW.) Addition of only the 70 MW off-site supply at this time would meet normal demand, but would not provide sufficient capacity to cover critical load in the event of an off-site supply outage. Installation of only the combined-cycle plant at this time could meet normal requirements, as well as critical loads with one gas turbine out of service. Considering the possibility that the full-capacity (70 MW) off-site supply might not be completed by January 1992 and the fact that to meet reliability criteria, the combined-cycle plant would be required by that date anyway, the single off-site power supply strategy was defined as installation of the 58 MW combined-cycle by the end of 1990 and installation of the full-capacity off-site supply no later than the end of 1994.

Results of model runs for this strategy (Alternative 3A) are included in the Attachment and are summarized as follows:

	With Digesters	Without Digesters
Present worth of capital expenditure ($1,000)	60,823	60,823
Present worth of operating expenditure ($1,000)	92,421	111,430
Total present worth ($1,000)	153,245	172,254

7.3.3 DUAL OFF-SITE SUPPLY OPTIONS

As with the single off-site power supply cases, it was determined that the first new permanent source of supply should be made available by the end of 1991. The remaining issue, then, was to determine the best time to schedule a second off-site supply and any on-site generation that might be justified by annual electric cost savings. With the two off-site supplies in place, no on-site capacity is required to meet minimum reliability criteria.

If no new on-site generation or immediate power supply is installed, the second permanent off-site supply is also required in late 1991 to cover the 1991 increases in critical loads, which would then exceed existing and committed on-site capacity. This defines the base dual-supply strategy of Alternative 1. This strategy may not be feasible, however, due to the uncertainty that the two off-site supplies can be installed by that date. Variations on the mixed source strategy (Alternative 3B) centered on the size of a single combined-cycle unit (15 or 25.7 MW) and the timing of both the on-site and second off-site sources. It was found that, with or without digesters, the alternative with the lowest present worth cost alternative would require the immediate and first off-site supply to be in service by the end of 1991 and the combined-cycle plant to be in place by the end of 1994. Very close in present worth cost, however, was a strategy requiring the combined-cycle plant to be in place first (1991) and the second off-site supply to be installed later (1994).

Results of the evaluation model runs are provided in the Attachment and are summarized in Table H-18.

7.4 CONCLUSIONS

7.4.1 OFF-SITE POWER SUPPLY

Differences in present worth costs between the single and the dual off-site power supply alternatives are relatively small. The dual off-site supply approach, however, provides significant flexibility in dealing with future loads, fuel prices, and electric rates.

TABLE H-9

DEER ISLAND CURRENT SERVICE PUMP DURATIONS FOR BASE LOAD DURATION CURVE

Number of pumps/ capacity (mgd)	Percentage of time	Annual hours of operation
Two/180	100	8760
Three/270	99.9	8750
Four/360	95	8320
Five/450	75	6570
Six/540	2	170
Seven/630	0.1	10
Eight/720	0.05	5
Nine/810	0.01	1

TABLE H-10

YEARLY kw HOUR DEMAND, 1986

Incremental	Load kw	hr/yr	kwh/hr
Minimum load*	4,500	8,760	39,420,000
+ third pump	1,500	8,750	13,125,000
+ fourth pump	1,500	8,320	12,480,000
+ fifth pump	1,500	6,570	9,855,000
+ sixth pump	1,500	170	255,000
+ seventh pump	1,500	10	15,000
+ eighth pump	1,500	5	7,500
+ ninth pump	1,500	1	1,500
Total			75,159,000

*Minimum load equals two influent pumps (3,000 kw) + house load (1,500 kw). The house load was determined from an actual measurement taken at the Deer Island facility.

4.4 HEATING DEMAND

The heating demand at the MWRA Deer Island wastewater treatment plant will increase as new facilities are constructed to provide improved wastewater treatment for increased volumes of wastewater. The heating load varies annually in accordance with the number of degree days/month. The average was varied in a stepped fashion to accommodate increases in flows and implementation of secondary treatment.

Total seasonal heating loads were determined by using published data that give seasonal steam demand per degree day per 1,000 ft^3 to be heated for the various types of buildings. This reflects hours per day of occupancy and required comfort levels. A value of 1,000 Btu/lb of useful heat is assigned to a pound of steam. For the buildings, a value of 0.962 lb steam/degree day/1,000 ft^3 was used. For the tunnel galleries, a value of 0.202 lb steam/degree day/1,000 ft^3 was used. This preliminary heating load estimate was based on an ultimate building volume of approximately 8,000,000 ft^3 and tunnel gallery volume of approximately 9,000,000 ft^3.

The number of degree days per month and the total degree days per heating season for Boston were obtained from the 1981 edition of the ASHRAE Fundamentals Handbook. They are shown in Table H-11, which also shows expected monthly heat loads.

In addition to the building heating load, a heating load for the anaerobic digesters may also exist. The heating load for the digestion process was calculated for the various levels of treatment, which include fast-track improvements in 1988, the addition of Nut Island flows in 1995, and the addition of secondary treatment in 1999. The average monthly heat loads for these milestones are tabulated in Table H-12.

4.5 DIGESTER GAS PRODUCTION

The anaerobic digestion process produces digester gas as a product while significantly reducing the weight of sludge requiring disposal. The digester gas produced consists primarily of methane, some carbon dioxide, and hydrogen sulfide. The heating value of the gas is estimated to be 600 to 650 Btu/scf. The amount of gas produced depends on the amount of volatile solids removed from the influent and the digester reduction efficiency.

The digester gas production was calculated for the various stepped improvements in treatment from 1988 to 1999 and is presented in Table H-13. The economics of using digester gas, if available, are discussed in Chapter 6.0.

TABLE H-11

HEAT LOAD PER MONTH BUILDING AND TUNNELS

Month	Degree days	Heat load/month (Btu x 10^6)
January	1088	16.634
February	972	14.860
March	846	12.934
April	513	7.843
May	208	3.180
June	36	550
July	0	0
August	9	138
September	60	917
October	316	4.831
November	603	9.219
December	983	15.029
TOTAL	5634	86.135

The seasonal heating load was calculated to be 52.438 x 10^6 Btu for building heating and 33.697 x 10^6 Btu for tunnel galleries. This results in a total seasonal heating load of 86.135 x 10^6 Btu and a heat demand of 15.3 x 10^6 Btu per degree day.

TABLE H-12

PROJECTED AVERAGE MONTHLY DIGESTER HEAT LOADS

Milestone date	Average monthly heat demand Btu/10^6
1988-1994	4.250
1995-1998	11.130
1999-2020	21.000

TABLE H-13

DIGESTER GAS PARAMETERS*

	Period		
	1986 to 1994	1995 to 1998	1999 to 2020
Sludge production (dry tons/day)			
Primary sludge production	58	163	177
Secondary sludge production	0	0	113
Total sludge production (solids)	58	163	290
Gas production			
Total Gas, Mcf/day	0.744	2.01	3.84
MBtu/day	446	1,254	2,304
MBtu/hr	18.6	52.26	96

The amount of digester gas produced is based on data provided by Black & Veatch in conjunction with Camp Dresser & McKee.

5.0 ALTERNATIVE 1: OFF-SITE PURCHASE OF ALL REQUIRED ADDITIONAL ENERGY

Alternative 1 consists of purchasing all the additional electric power required for the Deer Island treatment facility from Boston Edision Company (BECo). Because of the load size, BECo proposes to bring electric power to Deer Island at 115 kv, terminating at an on-island 115-kv switch yard. No additional on-site generating capacity beyond the two committed 6 MW dual fuel diesels is proposed.

5.1 RELIABILITY CONSIDERATIONS

Based on EPA regulations, a major portion of the electric power required at Deer Island falls into the critical service category and is therefore uninterruptible or essential as identified in Tables H-7 and H-8 respectively. BECo was informed of this requirement in a meeting on June 5, 1987. BECo responded that the requirement could be satisfied by bringing 115-kv cables capable of delivering 70 MW of power (normal supply) from the K street substation to Deer Island (submarine) and from BECo's station #488, Chelsea, to Deer Island via East Boston and across Logan Airport (buried and submarine). With these two cables in place from separate sources, the EPA reliability criterion is satisfied.

5.2 SCHEDULE TO PROVIDE ELECTRIC SERVICE

BECo has stated that with authorization as early as September 1987 they would envision a schedule for delivering the 115-kv electric service to Deer Island extending to mid-1991. The major activities that make up the project effort are the permitting activities and the engineering, fabrication, and construction of the cable trenches, cable and the switchyard. BECo's schedule is driven by the work load to which their staff is currently committed.

BECo did state in a meeting on June 5, 1987 that if certain activities could be performed by others, it might be possible to meet a required in-service date of January 1, 1990 to support construction of underharbor tunnels.

A schedule has been developed (Figure H-8) that, if adhered to, would permit BECo to deliver the 115-kv electric service from BECo's K Street substation by January 1, 1990. This schedule is contingent on completion of the permitting activities in ten months, which should be achievable. In addition, this schedule requires a commitment by BECo to perform engineering, procurement, and some fabrication simultaneously with the permitting activities and prior to permit receipt.

BECo has since negotiated with Massachusetts Electric Company (MECo) to supply the required 15-20 Mw of construction power. This source of supply will remain in service until the permanent power supplies are in place. The power will be delivered to BECo at 24 kv at the Winthrop/Boston line. MECo has assured BECo that meeting the required in-service date of January 1, 1990 is easily achievable since only 18 months is required to complete the installation. It is estimated that the cost for this service could be approximately $2.5 million dollars. If this service could be routed in the same trench as the proposed new water

main, savings of approximately $500,000 could be achieved.

This supply will be delivered via an underground transmission line originating from a substation in Winthrop. It is currently proposed that this service will terminate at a 24-kv to 13.8-kv temporary transformer owned by BECo to be located at the on-site electrical substation (see Volume III, Figure 11.1.3-1). MWRA will be responsible for the distribution system required to deliver the construction power where it is needed.

5.3 CAPITAL COST FOR PROVIDING ELECTRIC SERVICE

The costs for the various permanent power supply routes to Deer Island are outlined as follows (for all cost estimates, the most direct routes are assumed; for the trenching estimates, it is assumed that no serious problems will be encountered, such as ledge or bedrock):

1. Submarine cables from K Street to Deer Island

   Distance: 20,500 ft

   Construction: Four 400-KCmil copper single-phase submarine cables ($32/ft) in one trench (10 ft deep in ship channels and 5 ft deep in other areas)

   Cost in 1987 dollars: $8,900,000

   Cost of one 115-kv circuit breaker at K Street: $225,000

2. Buried and submarine cables from station #448, Chelsea to Deer Island via East Boston and across Logan Airport

   Distance: 10,500 ft

   Construction: Four 400-KCmil copper single-phase buried and submarine cables for entire length in one trench

   Cost in 1987 dollars: $10,000,000

   Cost for one 115-kv circuit breaker at station #448: $225,000

3. Two separate submarine cables from K Street to Deer Island with eight single-phase cables in one trench (no service from Chelsea)

   Cost in 1987 dollars: $12,500,000

   Cost of two 115-kv circuit breakers at K Street: $450,000

Extra cost for two trenches: $2,750,000

Note: Option 3 does not comply with the EPA requirement of having two separate sources of supply in order to be considered uninterruptible. For that reason, it should not be considered further.

BECo's policies which will affect their evaluation of the preceding costs are:

1. BECo will provide one source of supply in the public way at BECo expense, not to exceed 1.5 times the annual estimated revenue. An executed agreement between MWRA and BECo to that effect would be required.

2. Said agreement would also require payment for all additional work over the normal supply. Normal supply is four 400-KCmil copper single-phase cables in a single trench from the K Street substation. The capital costs would be:

$8,900,000	for cable trenching
225,000	for circuit breaker at K street
$9,125,000	total

BECo would, thus, require a $6,085,000 annual revenue to support this $9 million investment. If this return is not achievable, that portion of the capital cost that could not be recovered in 18 months would be passed on to MWRA.

Based on BECo's requirements for capital investment, the annual revenue of $6,085,000 to support its capital investment in a 115-kv cable from K Street will not be achieved until 1995. Therefore, negotiations with BECo will be required to determine if an in-service date prior to 1995 for this 115-kv cable will result in additional capital charges to MWRA.

When performing the economic evaluation of this alternative, the capital costs of approximately $4,500,000 for construction of the MWRA-owned substation and maintenance costs were not included since the substation is common to all supply alternatives.

6.0 ALTERNATIVE 3: COMBINED ON-SITE GENERATION AND OFF-SITE PURCHASE

Alternative 3 consists of purchasing primary electric power from BECo and providing electric power from additional on-site generation. Primary electric power can be delivered to Deer Island either by submarine cable from K Street or by buried and submarine cable from Chelsea via East Boston and across Logan Airport, as discussed in Section 5.0. Primary electric power would be delivered at 115 kv to the MWRA-owned switchyard.

For the single cable off-site supply option, backup electric power would be self-generated by a combined-cycle plant, capable of generating up to 58 MW plus two 6-MW diesel generators, for a total capacity of 70 MW. The combined-cycle plant would consist of two combustion turbine-generators (rated at 20 MW each when ambient temperature is 88° F conditions) exhausting to two heat-recovery steam generators (HRSG), which, combined, produce sufficient steam to generate 18 MW in a single steam turbine-generator. The HRSGs would be supplementary-fired to utilize the complete combustion capacity of the exhaust gas.

An auxiliary boiler would provide backup to meet essential power demand in case one of the two trains that make up the combined-cycle plant is not operable to back up the primary electric power supply from BECo. The auxiliary boiler would produce sufficient steam to generate an additional 10 MW in the steam turbine-generator. The auxiliary boiler would also be capable of supplying full steam requirements for heating demand.

The potential on-site generating capacity is tabulated in Table H-14. It shows the methodology of the power generation facilities to meet both peak power demand and essential power demand, assuming the unavailability of any single power generating component.

6.1 RELIABILITY CONSIDERATIONS

The EPA requires two independent sources of electric power at full capacity to ensure reliability of operation of waste treatment facilities. To satisfy this requirement, the on-site power generation facilities, comprised of the 58-MW combined-cycle power plant, the auxiliary boiler, and the two diesel generators, would provide 100-percent backup capability to the primary power supply from BECo. In addition, the on-site power generation facilities would be capable of supplying essential peak electric power demand (as shown in Table H-8) in case the largest component of the power generation facility is out of service coincident with an interruption of primary service from BECo.

Additional reliability is provided through the design process by specifying high quality equipment from experienced and prequalified suppliers and by providing redundancy of equipment where justified.

6.2 ECONOMIC SELF-GENERATION CAPACITY

The digester gas produced in the waste treatment process can be used as fuel in the combustion turbines. The electricity generated can be used to shave the quantity of purchased electricity during peak price periods, which are 10^{6} hours per day Monday through Friday.

TABLE H-14

ON-SITE GENERATING CAPACITY

	Capacity (kW)		
	Each	All Facilities Available	Single Largest Component Unavailable*
Combustion turbine-generators (2)	20,000	40,000	20,000
Steam turbine generators (2)			
Steam from HRSG (2)	9,000	18,000	9,000
Steam from auxiliary boiler	10,000	**	10,000
Diesel generators (2)	6,000	12,000	12,000
Total		70,000**	51,000

* Unavailability of a single component (e.g., the combustion turbine/generator or HRSG) would result in isolation of one train of the combined cycle plant.

** Normal operation to satisfy peak demand would not require the auxiliary boiler, which is provided as backup.

Since digester gas is produced continuously, it would have to be stored during off-peak hours for consumption during peak hours. A storage capacity of 16 hours is sufficient. It is assumed that digester gas would be burned as produced on weekends, since weekends are offpeak hours.

Digester gas production increases to 2,304 x 10^6 Btu/day in 1999 (see Table H-13). Consumption of this gas during the 10-hour peak period results in 230 x 10^6 Btu/hr. The combustion turbines can generate approximately 27 MW burning the digester gas, which translates into a daily reduction in electricity purchase of 270,000 kw-hr.

Burning digester gas represents the most economical self-generation capacity, because if the gas is available it has no cost. Related costs do apply, however, including cost of equipment required to store and transfer the gas, cost of operating personnel, and maintenance costs.

6.3 CAPITAL COST OF CAPACITY

The preliminary capital cost estimate of the on-site generation facilities is based on vendor quotes for a combined-cycle plant and an interconnected auxiliary boiler. These costs are presented in Table H-15. The diesel generators will be added as part of the Fast-Track Improvements Program and are not included in the cost estimate.

The cost estimate assumes a combustion turbine as the basis for sizing and selecting components for the combined-cycle plant.

Budgetary prices were solicited from Stewart & Stevenson Services, Inc., and Solar Turbines, Inc. The capital cost estimate is based on this input combined with Stone & Webster's in-house cost-estimating data and experience.

An option evaluated under the partial self-generation alternative was a reduced-size combined-cycle plant plus two off-site feeders. This plant was sized to provide the most cost-effective mix of off-site purchase and self-generated power.

Combined-cycle plants having a capacity of 25,700 kw and 15,000 kw were considered. Budgetary prices were obtained from the vendors who had supplied pricing for the 58,000 kw plant. These capital cost estimates are also presented in Table H-15. It was determined that a combined-cycle unit having a capacity of 25,700 kw at ambient temperature conditions of 88° F is the most economical choice.

6.4 OPERATING AND MAINTENANCE COST OF CAPACITY

The operating and maintenance cost for the on-site generation facilities comprises variable costs for fuel, maintenance equipment, spare parts, and fixed costs for operating and maintenance personnel.

TABLE H-15

PRELIMINARY CAPITAL COST ESTIMATE FOR ON-SITE GENERATING CAPACITY

	58 MW ($\$ \times 10^6$)	25.7 MW ($\$ \times 10^6$)	15 MW ($\$ \times 10^6$)
Plant direct costs (including auxiliaries, foundations, buildings)			
Combustion turbine-generators	18.7	8.2	5.1
Heat recovery steam generators	6.3	3.0	1.4
Steam turbine-generator	7.8	3.0	1.4
Heat rejection system	1.0	0.5	0.6
Auxiliary boiler	0.5		
Miscellaneous	1.7	0.8	0.7
Subtotal direct costs	36.0	15.5	9.2
Indirect costs (including contingencies, allowance for funds used during construction, engineering, and construction management)	18.0	7.8	4.6
Total installed cost, 1987 Dollars	54.0	23.3	13.8

The price of distillate fuel used as the basis for the economic evaluation in Chapter 7.0 is $\$3.75/10^6$ Btu, or 52¢ per gallon. The actual fuel price at the time of operation, of course, will vary with market conditions. Based on the price, the fuel cost for the combined-cycle plant would be $0.035/kwh of generation. The most economic dispatching scenario for the on-site generating capacity will determine the annual fuel cost. This is discussed in Section 7.0.

The remaining operating and maintenance costs, excluding fuel, can be estimated at $40/kw-yr for these sizes of combined-cycle plants. This results in an annual cost of $2,500,000 and $1,030,000, respectively, which is used as part of the economic evaluation in Section 7.0.

7.0 ECONOMIC EVALUATION OF POWER SUPPLY ALTERNATIVES

7.1 INTRODUCTION

The objective of this section is to evaluate alternative strategies to meet the electric power demands of the Deer Island facility. An earlier study entitled "Preliminary Screening of Energy Supply Alternatives" concluded that a combination of on-site and off-site power sources is the appropriate approach. This evaluation looks at that approach in greater detail to determine the optimal number of independent off-site supplies and the optimal amount of on-site generation.

The two major alternatives presented in the preceding chapters and several variations were evaluated in terms of life-cycle present worth cost. Alternative 1, reflecting a strategy of purchasing most primary and all backup power from an electric utility (e.g., BECo), requires the installation of two independent off-site supplies, but no additional on-site generating capacity beyond the two committed 6-MW dual-fuel diesels.

Alternative 3 reflects a strategy of optimizing the mix of off-site and on-site power sources to minimize life-cycle cost. Options evaluated within this alternative included:

3A: A single off-site source and a two-unit combined cycle plant

3B: Two off-site sources and a single unit combined cycle plant.

Option 3B was evaluated with several different schedules for installation of the second off-site supply and the combined cycle unit.

Economic evaluations consisted of comparing the present worth of expenditures for power purchases, fuel purchases, operation and maintenance of generation capacity, and capital costs for off-site power supplies and new on-site generation capacity over a study period from 1991 to 2020. In each case evaluated, the same electric loads were met, as were the building heating loads. The evaluations were conducted twice, once assuming that digesters would be included in the facility, once assuming that they would not. The digesters require additional heating steam, but they provide a "free" source of fuel for the committed dual-fuel diesels and/or for combined-cycle units. Present electric rates and fuel costs were used, without real escalation. A real discount rate of 8.625 percent was used. Results are summarized in Table H-16.

7.2 ASSUMPTIONS

To perform an economic evaluation, it is necessary to make several assumptions regarding prices, electric rates, and acceptable financial performance. This subsection documents those assumptions.

TABLE H-16

ECONOMIC EVALUATION OF ALTERNATIVES

	Alternative 1 Dual off-site supply, no new generation	Alternative 3A Single off-site supply, 58 MW CC*	Alternative 3B Dual off-site supply, 25.7 MW CC
WITH DIGESTERS			
Present worth of capital expenditure ($1000)	20,100	60,823	40,423
Present worth of operation expenditures ($1000)	122,480	92,421	99,194
Total present worth ($1000)	142,580	153,244	139,617
WITHOUT DIGESTERS			
Present worth of capital expenditure ($1000)	20,100	60,823	40,423
Present worth of operation expenditures ($1000)	141,396	111,430	117,922
Total present worth ($1000)	161,496	172,253	158,345

* CC = combined cycle

7.2.1 ELECTRIC RATES

Power would be purchased from BECo at 115 kv under a rate similar to General Services Rate G-3, which is summarized in Table H-17. The G-3 rate is based on 13.8-kv service. It was assumed that the electric rates would remain stable in constant dollar terms (that is, they will increase at roughly the same rate as other prices in general).

7.2.2 FUEL

The price of #2 distillate oil (diesel fuel) delivered to Deer Island is roughly 52¢/gal, or $3.75/MBtu. Fuel costs are also assumed to remain stable in real terms. The price of natural gas, if it were available, would be about the same in the current market. Boston Gas has determined that it would have to assess a capital charge of $5,000,000 to provide adequate gas service for a combined-cycle power plant on Deer Island. Boston Gas has not committed sufficient reserves to meet such a demand year-round. For this reason, it is assumed for the purposes of this study that all fuel (other than digester gas) used at the facility will be distillate oil. However, MWRA should continue to investigate the availability and cost of natural gas.

7.2.3 ECONOMIC CRITERIA

Economic comparisons are based on the present worth of future expenditures (life-cycle costs) from 1991 to 2020 measured in 1987 constant dollars and discounted at a real rate of 8.625 percent per year, in accordance with guidelines established for the project. It is assumed that the 8.625 percent represents weighted cost of capital for MWRA and that an incremental investment will be attractive to MWRA if it has an internal rate of return in excess of that value.

7.3 EVALUATION OF ALTERNATIVES

This subsection describes the process of selecting and evaluating alternative power supply strategies.

7.3.1 EVALUATION MODEL

A spreadsheet model was developed to simulate the operation of various power supply strategy alternatives over the 30-year study period and to calculate the present worth of expenditures for capital and operational costs.

The first section of the model consists of assumptions and data common to all alternatives in a comparison: discount rate, base years for prices and present worth, fuel prices, electric rates, general descriptions of generating units, a non-dimensional electric load duration curve, forecast peak electric loads for each group of years, forecast heating loads and digester gas quantities, and retirement schedules for existing and committed capacity. This section also contains intermediate calculations of items such as period present worth factors

TABLE H-17

BECO PURCHASE POWER RATES

Demand charge(a)

November-June:	$6.74/kw-mo.
July-October:	$15.76/kw-mo.

Energy Charge(a)

	Onpeak hrs	Offpeak hrs(b)
November-June:	2.912¢/kWH	0.703¢/kwh
July-October:	3.046¢/kWH	0.472¢/kwh

Fuel adjustment charge(c): 2.047¢/kWH

NOTES:

(a) Taken from the Boston Edison Company's General Service Rate G-3, effective 16 July 1986.

(b) On-peak hours: 8 a.m. - 9 p.m. EST, 9 a.m. - 10 p.m. EDT, weekdays.
Off-peak hours: all other hours

(c) Provided by Peter Moloney of BECo over telephone on 24 September 1986; applicable from August through October of 1986.

and minimum required capacity. Table A-1 in the Attachment is a printout of this section of the spreadsheet.

The next section of the spreadsheet consists of input describing a particular strategy alternative and the resulting capital expenditures, energy balances, annual costs, and total present worth of costs. Table A-2 in the Attachment is a sample printout of such a section. A final section consists of working tables used to dispatch load to available power sources during each time period.

The total present worth cost is the sum of the present worth of capital expenditures and the present worth of operating expenditures. Peak and off-peak purchased energy are calculated through a dispatch algorithm that uses the load duration curve and allocates horizontal bands of its area (total energy) to supply sources as the basis of incremental cost and capacity (adjusted for availability). When digester gas is available, the energy it can produce in the committed 6-MW diesels and any new combined-cycle capacity is dispatched first at zero cost. After that, the incremental cost of power from the engines and combined-cycle units burning distillate oil is compared with the peak or off-peak purchase rate plus fuel adjustment charge to determine if on-site capacity should be operated or left in reserve. On-site generation is adjusted for extraction steam where appropriate. Off-site purchases fill in any energy requirements not met by the on-site capacity.

Fuel consumption and annual expense are determined based on the operation of each on-site generating source and on the amount of heating load that cannot be met by means of cogeneration. Operation and maintenance expense is based on installed on-site generation capacity.

7.3.2 SINGLE OFF-SITE SUPPLY OPTIONS

An additional power source, beyond existing and committed on-site generation and MECo capacity, will be required at Deer Island by the beginning of 1992. At that time, peak loads are forecast at 28.85 MW (plus 6-MW for engine-driven pumps), while capacity adjusted for outage of the largest unit (N-1 capacity) would be 9.5 MW. (Critical load at that time would be 25.05 MW.) Addition of only the 70 MW off-site supply at this time would meet normal demand, but would not provide sufficient capacity to cover critical load in the event of an off-site supply outage. Installation of only the combined-cycle plant at this time could meet normal requirements, as well as critical loads with one gas turbine out of service. Considering the possibility that the full-capacity (70 MW) off-site supply might not be completed by January 1992 and the fact that to meet reliability criteria, the combined-cycle plant would be required by that date anyway, the single off-site power supply strategy was defined as installation of the 58 MW combined-cycle by the end of 1990 and installation of the full-capacity off-site supply no later than the end of 1994.

Results of model runs for this strategy (Alternative 3A) are included in the Attachment and are summarized as follows:

	With Digesters	Without Digesters
Present worth of capital expenditure ($1,000)	60,823	60,823
Present worth of operating expenditure ($1,000)	92,421	111,430
Total present worth ($1,000)	153,245	172,254

7.3.3 DUAL OFF-SITE SUPPLY OPTIONS

As with the single off-site power supply cases, it was determined that the first new permanent source of supply should be made available by the end of 1991. The remaining issue, then, was to determine the best time to schedule a second off-site supply and any on-site generation that might be justified by annual electric cost savings. With the two off-site supplies in place, no on-site capacity is required to meet minimum reliability criteria.

If no new on-site generation or immediate power supply is installed, the second permanent off-site supply is also required in late 1991 to cover the 1991 increases in critical loads, which would then exceed existing and committed on-site capacity. This defines the base dual-supply strategy of Alternative 1. This strategy may not be feasible, however, due to the uncertainty that the two off-site supplies can be installed by that date. Variations on the mixed source strategy (Alternative 3B) centered on the size of a single combined-cycle unit (15 or 25.7 MW) and the timing of both the on-site and second off-site sources. It was found that, with or without digesters, the alternative with the lowest present worth cost alternative would require the immediate and first off-site supply to be in service by the end of 1991 and the combined-cycle plant to be in place by the end of 1994. Very close in present worth cost, however, was a strategy requiring the combined-cycle plant to be in place first (1991) and the second off-site supply to be installed later (1994).

Results of the evaluation model runs are provided in the Attachment and are summarized in Table H-18.

7.4 CONCLUSIONS

7.4.1 OFF-SITE POWER SUPPLY

Differences in present worth costs between the single and the dual off-site power supply alternatives are relatively small. The dual off-site supply approach, however, provides significant flexibility in dealing with future loads, fuel prices, and electric rates.

TABLE H-18

PRESENT WORTH COSTS OF DUAL OFF-SITE POWER SUPPLY OPTIONS

	Alternative 1, no new generation	Alternative 3B: Second off-site in 1991, C.C. in 1994	Alternative 3B: Second off-site in 1994, C.C. in 1991
WITH DIGESTERS, $1000			
PW of capital expenditure	20,100	36,843	40,423
PW of operating expenditure	122,480	102,718	99,194
Total PW cost	142,580	139,561	139,617
WITHOUT DIGESTERS, $1000			
PW of capital expenditure	20,100	36,843	40,423
PW of operating expenditure	141,396	121,494	117,922
Total PW cost	161,496	158,337	158,345

7.4.2 ADDITIONAL ON-SITE GENERATION

Whether or not a second off-site power supply is provided, on-site generation has value in that it reduces demand and peak energy charges from BECo. A large, two-unit 58 MW station is required in the case of the single off-site supply to cover critical loads in the event of a power failure coincident with a generating unit that is out of service. In the dual off-site supply case, economics indicate that a unit in the 25-MW size range is appropriate. This unit, in conjunction with existing and committed capacity, could generate most of the facility's normal loads during peak electric rate periods and could provide a major portion of critical loads, even during a massive blackout condition that might affect both off-site supplies. Considering the uncertainty regarding the date when a second off-site supply could be installed, the strategy of installing the combined-cycle plant before the second off-site supply is installed is the most attractive, despite a slightly higher present worth cost.

7.4.3 IMPACT OF DIGESTERS

The use of digesters in the treatment process, with their associated heating loads and gas production, results in a reduction of present worth energy costs, regardless of the strategy selected. Most of the gas can be used in the already committed dual-fuel diesel engines, and the heat load can be met by waste heat from those engines. Consequently, the choice of power supply strategy is not affected by the existence or nonexistence of the digesters. Differential present worth costs among the strategies evaluated are similar in either situation.

7.4.4 SENSITIVITY OF RESULTS

Fuel Price and Electric Rates

If fuel price were to change dramatically relative to power cost and capital costs, the lowest present worth strategy would be different. An increase from $3.75/MBtu to $6.00/MBtu would make the dual off-site supply/no new on-site generation alternative the preferred choice. It is likely, however, that such a large fuel price increase would be partially offset by higher electric rates. With a decrease to $2.00/MBtu, however, the preferred choice remains dual off-site supply with a small combined-cycle plant. It is unlikely that a slightly lower electric rate than the one used (G-3 at 115 kv vs at 13.0 kv) would change the preferred alternative. The effect of higher electric rates would be similar to that of lower fuel costs, encouraging additional on-site generation.

Discount Rate

If the effective cost of capital to the MWRA is lower than 8.625 percent (real), this would favor a larger combined cycle-plant, with or without a second off-site supply. A substantially higher cost of capital would tend to favor the dual off-site supply/no new on-site generation alternative.

8.0 ENVIRONMENTAL CONSTRAINTS

8.1 AIR QUALITY

Estimates of the potential air quality impacts associated with the operation of power- and heat- generating equipment for the Deer Island wastewater treatment plant were made for the various project phases relative to existing operations and for comparison with air quality standards. The applicable ambient air quality standards for the Commonwealth of Massachusetts are the same as the National Ambient Air Quality Standards (NAAQS) and are shown in Table H-19. The primary standards are designed to protect the public health, with an adequate margin of safety, while secondary standards define levels considered necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. According to the Massachusetts Air Pollution Control Regulations (310 CMR 7.02), fossil and wood fuel utilization facilities that have energy-input capacities greater than 3 million Btu/hour require approval by the Department of Environmental Quality Engineering (DEQE). This approval is based in part on the condition that emissions from the facility would not result in any violations of NAAQS. In addition, the DEQE has established a 1-hour NO_2 guideline of 320 ug/m^3 applicable to new or modified major sources of NO_x. DEQE policy states that any new source or modification of an existing source that will result in increased emissions of 250 tons or more per year must show it will not cause more than one exceedance per year of the 320 ug/m^3 guideline at any location with consideration of background levels. In addition, a new or modified major source of NO_x must not increase hourly NO_2 concentrations by more than 32 ug/m^3 on more than one day per year when ambient hourly NO_2 concentrations in excess of 320 ug/m^3 are predicted to occur.

In addition, a modification to a major source (potential to emit $\geq$ 100 tons/year) located in a non-attainment area (ambient pollutant concentrations exceed NAAQS) resulting in a significant increase in emissions of the pollutant in non-attainment, must comply with the provisions of 310 CMR 7.00, Appendix A (1)-(6), Emissions Offsets and Non-attainment Review. Since carbon monoxide (CO) and ozone are the only pollutants in non-attainment in Boston, an increase in CO emissions of 100 tons/year or more or an increase in emissions of volatile organic compounds (VOC) of 40 tons/year or more would require compliance with 310 CMR 7.00, Appendix A (1)-(6).

Along with the state regulations, the federally-mandated Prevention of Significant Deterioration (PSD) requirements may also apply, depending on the level of annual increases of the emitted pollutants. Increases in pollutant emissions would be determined relative to a baseline emission rate, usually determined as the average of the most recent two years of emissions inventory at the time of application as confirmed by DEQE to be representative of the current facility operation. If these increases in pollutant emissions are significant as defined in 40 CFR 51.24, increases in pollutant concentrations over the baseline concentrations are limited to the available portion of the ambient air increments, as shown in Table H-20.

In regard to emissions limitations, Massachusetts has been delegated to administrate compliance with the federal New Source Performance Standards (NSPS). NSPS (Subpart GG) are applicable to gas turbines, which must approximate NO_x emission concentrations of 75 ppm for heat input rates greater than 100 million Btu/hr and 150 ppm for heat-input rates between 10 and 100 million

TABLE H-19

STATE AND NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging interval	Primary Standard $\mu g/m_3$	Primary Standard ppm	Secondary Standard $\mu g/m_3$	Secondary Standard ppm
Sulfur dioxide	Annually	80	0.03	-	-
	24 hours	365	0.14	-	-
	3 hours	-	-	1,300	0.5
Total Suspended Particulates	Annually	75	-	60	-
	24 hours	260	-	150	-
Inhalable Particulates*	Annually**	50	-	50	-
	24 hours***	150	-	150	-
Carbon monoxide	8 hours	10****	9	10****	9
	1 hours	40****	35	40****	35
Ozone	1 hour	240	0.12	240	0.12
Nitrogen dioxide	Annually	100	0.05	100	0.05
Lead	3 months	1.5	-	1.5	-

$\mu g/m^3$ - micrograms per cubic meter
ppm - parts per million

* includes particles with an aerodynamic diameter $\leq$ 10 micrometers
** expected annual arithmetic mean
*** no more than one expected exceedance per year
**** mg/m^3 (milligrams per cubic meter)

TABLE H-20

PREVENTION OF SIGNIFICANT DETERIORATION (PSD), SIGNIFICANT EMISSIONS INCREASES, AND AMBIENT AIR INCREMENTS

1. Significant emissions increases

Pollutant	Emission rate (tons/year)
Carbon monoxide	100
Nitrogen oxides	40
Sulfur dioxide	40
Particulate matter	25
Ozone	40 (volatile organic compounds)

2. Ambient air increments*

Pollutant	Concentration ($\mu g/m^3$)		
	3hour	24hour	Annual
Particulate matter	N/A	37	19
Sulfur dioxide	512	91	20

* Class II increments

Btu/hr. There is also a sulfur dioxide (SO_2) NSPS of 0.015 percent by volume for gas turbines, and the fuel cannot contain greater than 0.8 percent sulfur by weight. However, Massachusetts has adopted a sulfur in fuel limitation (310 CMR 7.05) which would restrict the sulfur content of distillate fuel oil to approximately 0.3 percent for facilities located in Boston. In addition, Massachusetts requires the use of Best Available Control Technology (BACT) for any facility modification resulting in changes in pollutant emissions. BACT is defined as an emission limitation based on the maximum degree of reduction for each applicable pollutant that the reviewing authority determines is achievable on a case-by-case basis, taking into account energy, environmental, and economic impacts.

The first step in this air quality analysis consists of characterizing pollutant emissions and resulting air quality impacts associated with the existing equipment, which consists of eight 1,500-kw Nordberg diesel engines and five 700-kw Enterprise diesel generators operated as required to meet power demand, as well as four heating boilers. The pollutant emissions and air quality impacts associated with the addition of two 6,000-kw engines (fast-track improvements in 1988) are then examined for Alternative 1 (off-site purchase) and compared with the emissions and impacts associated with existing operations on Deer Island. The Nordberg, Enterprise, and 6,000-kw diesels constitute the "committed capacity". Finally, the pollutant emissions and associated impacts for Alternatives 3A and 3B (combination on-site/off-site generation), for which on-site capacity is added via combined cycle plant(s), are assessed in relation to the current air quality impacts and applicable standards.

The various combinations of diesel pumps and generators that constitute the committed capacity and the new combined cycle plant(s) associated with primary and secondary treatment facilities are shown in the Appendix. Retirement of committed capacity units is addressed in Table H-21.

This air quality impact analysis is performed using EPA computer models along with estimates of pollutant emissions obtained from EPA publications and equipment vendor data. Refined modeling using five years of meteorological data is performed. Information on stack parameters needed for computer modeling is obtained from DEQE Form DDS-1 and from vendor-supplied data. In addition, estimates of background concentrations of the criteria pollutants on Deer Island are obtained from monitoring data published by the DEQE. The details of the analysis are described in the following subsections.

8.1.1 EMISSIONS CHARACTERISTICS

The emissions characteristics needed to model the air quality impact of each piece of equipment include stack height, inside stack diameter, exit velocity, exit temperature, and pollutant emission rate. This information is obtained for the Nordberg diesel pumps, Enterprise and Delaval diesel generators as well as for the Cleaver Brooks heating boilers from DEQE Form DDS-1. The maximum stack gas volumetric flows from Form DDS-1 used to calculate maximum exit velocities and maximum exit temperatures are taken directly from the form.

Stack data for the proposed combined cycle plant for Alternatives 3A and 3B are based on vendor information available for a 22-MW gas turbine. The gas-turbine emission height used in the

TABLE H-21

DEER ISLAND FOSSIL-FUELED EQUIPMENT INVENTORY

Period	Nordberg diesels Oper. (No.)	Nordberg diesels Stdby. (No.)	Nordberg diesels ALF (%)	Enterprise diesels Oper. (No.)	Enterprise diesels Stdby. (No.)	Enterprise diesels ALF (%)	Delaval diesels Oper. (No.)	Delaval diesels Stdby. (No.)	Delaval diesels ALF (%)	Combined cycle (a) Oper. (No.)	Combined cycle (a) Stdby. (No.)	Combined cycle (a) ALF (%)
Baseline	4	4		2	3							
1988-1989	1	4	2	4	1	2	1	1	100			
1990-1994	1	4	2	4	1	100	1	1	100			
1995-1998												
- Alt 3A							1	1	24	2	0	17
- Alt 3B							1	1	24	1	1	33
1999-2020												
- Alt 3A							1	1	24	2	0	24
- Alt 3B							1	1	63	1	1	33
Boilers (all periods)	3	1	42									

(a) Alternative 3 only
Oper. = Operating
Stdby. = Standby
ALF = Annual Load Factor

modeling are 37.3 m (122.5 ft), based on the EPA Good Engineering Practice Stack Height formula of 2.5 times the height of adjacent structures, which in this case is anticipated to be 14.9 m (49 ft). Preliminary indications are that this stack height will pose no difficulties for air traffic at Logan Airport. The stack parameters for all equipment are given in Table H-22.

With the exceptions of the 6,000-kw Delaval diesel generators and combined cycle plant, the emission rates of the criteria pollutants from all equipment, including nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), volatile organic compounds (VOC), and total suspended particulates (TSP), are estimated using EPA publication AP-42. Vendor-supplied information is used for the 6,000 kw Delaval diesel generators and combined cycle plant. The emissions estimates for the diesels assume no flue-gas controls, while the gas-turbine emissions assume the use of water injection to reduce NO_x emissions to 75 ppm by volume while burning distillate which meets NSPS and is guaranteed by the manufacturer. The SO_2 emissions from the gas turbines are estimated to be less than 60 ppm by volume, which is well below the NSPS of 150 ppm. The costs developed in Section 5 include an allowance for steam or water injection. The diesel emissions of SO_2 assume the use of 0.3 percent sulfur diesel fuel. The estimated pollutant emission rates from all equipment at full load are given in Table H-23.

Additionally, it was assumed that digester gas would not be available for use as a supplemental fuel. The use of digester gas in the diesels would reduce the estimated SO_2 emissions by approximately 75 percent and NO_x emissions by about 25 percent. In estimating pollutant emission rates for predicting air quality impacts associated with 1 hour, 3 hour, 8 hour, and 24 hour emission rates, it was assumed that each piece of equipment would operate at 100 percent capacity. These fuel-use assumptions provide the worst-case estimates of pollutant emissions for the project. It should be noted that the assumed gas turbine emissions meet minimum requirements and do not necessarily reflect the emissions that would actually be permitted. These emissions would be determined at the time a BACT analysis is approved by DEQE.

Pollutant emissions rates for Alternatives 1, 3A and 3B for average and peak wastewater flows for each project phase are given in Table H-24. The only difference among Alternatives 1, 3A and 3B is the addition of the combined cycle plant in 1995 for Alternatives 3A and 3B. The baseline emissions are preliminarily based on actual fuel usage for 1974-1976 from Form DDS-1. In all cases, annual emissions are based on the preliminary equipment dispatching information provided in Section 7. Also, Table H-21 shows the combination of equipment assumed in estimating the emissions shown in Table H-24. Table H-24 indicates that annual NO_x emissions will increase for the 1988-1989 and 1990-1994 project phases and decrease for the 1995-1998 and 1999-2020 phases. The largest increase in annual NO_x emissions occurs in the 1990-1994 project phase with an annual increase of 606 tons/yr. SO_2 emissions will increase for all project phases, except for Alternative 1 in the 1995-1998 project phase, with the largest increase of 123 tons/year occurring in the 1999-2020 project phase for Alternative 3A. The annual CO, TSP, and VOC emissions will decrease for all project phases.

It should be noted again that the use of digester gas in the 6,000-kw Delaval diesels would significantly reduce the NO_x and SO_2 emissions for the committed capacity. In addition, the current practice of flaring digester gas has not been taken into account in the existing

TABLE H-22
STACK PARAMETERS

Equipment	Stack height (m)	Stack diameter (m)	Exit velocity (m/sec)	Exit temperature (° K)
Nordberg diesel engine (1.5 MW)	15.2	0.56	18.9	478
Enterprise diesel generator (0.7 MW)	13.7	0.36	22.7	700
Delaval diesel generator (6 MW)	15.2	1.07	14.8	733
Cleaver Brooks heating boilers	15.2	1.37	3.9	589
Gas turbine (22 MW)	37.3	2.20	27.4	533

TABLE H-23

POLLUTANT EMISSION RATES FOR ALL OPERATING EQUIPMENT (1)

	Pollutant Emission Rate (lbs/hr)				
Equipment	NOx	SO_2	CO	TSP	VOC
Nordberg diesel engine	60.0	5.4	15.6	6.0	1.6
Enterprise diesel generator	30.0	2.7	7.8	3.0	0.8
Delaval diesel generator	171.4	19.1	9.1	0.6	0.4
Cleaver Brooks heating boiler	4.7	4.0	0.4	0.6	0.02
Gas turbine (22 MW)	94.1	70.0	29.2	5.0	1.1

(1) See Table H-21 for operating conditions.

TABLE H-24

POLLUTANT EMISSION RATES FOR ALTERNATIVES 3A AND 3B

Year	Pollutant Emission Rate				
	NOx	SO_2	CO	TSP	VOC
Baseline					
Avg. flow (a)	702	66	182	70	18
Peak flow (b)	314	39	79	32	8
1988-1989					
Avg. flow	793	108	46	8	2
Peak flow	365	47	57	32	5
1990-1994					
Avg. flow	1,308	154	180	57	16
Peak flow	365	47	57	32	5
1995-1998					
Alternative 1					
Avg. flow	251	47	14	4	1
Peak flow	185	31	10	2	0.5
Alternative 3A					
Avg. flow	346	146	55	11	2
Peak flow	74	171	69	12	3
Alternative 3B					
Avg. flow	342	143	54	11	2
Peak flow	280	101	40	7	2
1999-2020					
Alternative 1					
Avg. flow	251	47	14	4	1
Peak flow	185	31	10	2	0.5
Alternative 3A					
Avg. flow	404	189	73	14	3
Peak flow	374	171	69	12	3
Alternative 3B					
Avg. flow	635	176	70	12	3
Peak flow	280	101	40	7	2

(a) Average flows are measured in tons/yr.

(b) Peak flows are measured in lbs/hr.

emissions (baseline). Using digester gas in the diesels could result in significant net decreases in NO_x and CO emissions. In one documented case, the use of digester gas as a diesel fuel created a net 50-percent decrease in emissions of NO_x and CO, compared to what the site released when the bulk of the gas was flared.

The predicted impacts of these emissions on ambient air quality are discussed below.

8.1.2 BACKGROUND AIR QUALITY

Background air quality concentrations are determined from the air quality monitoring data published by the Massachusetts DEQE. Wherever possible, data from the Deer Island monitoring station are used to determine background concentrations. For averaging times less than annual average, the second highest monitored value from the latest three years of data was chosen as background. The largest annual average value for the three most recent years of data was also chosen as background. If data from Deer Island were not available for a given pollutant, the second highest monitored values from nearby stations (Long Island, East Boston, Chelsea) for the three most recent years of data were chosen.

Background NO_2 concentrations at Deer Island are estimated to be 61 $\mu g/m^3$ on an annual basis. This concentration is based on a 1984 monitored value of 61 $\mu g/m^3$ at East Boston. This could be considered a conservative value, since the only valid annual NO_2 concentration monitored on Deer Island itself was 28 $\mu g/m^3$ in 1983.

For SO_2, 3- and 24-hour concentrations of 303 $\mu g/m^3$ and 238 $\mu g/m^3$ were chosen as background levels for Deer Island. The 3-hour SO_2 concentration was the second highest recorded in East Boston in 1985, and the 24-hour value was the second highest monitored on Long Island in 1984. Again, these are considered to be conservative values since the only recorded 3- and 24-hour second highest SO_2 concentrations on Deer Island were 121 and 115 $\mu g/m^3$, respectively. The annual average SO_2 background concentration of 34 $\mu g/m^3$ was recorded at East Boston in 1984.

For CO, 1-hour and 8-hour concentrations of 14,000 $\mu g/m^3$ and 10,000 $\mu g/m^3$ were chosen for background at Deer Island, based on 1984 and 1983 monitoring results, respectively, in East Boston. There are no CO data available for Deer Island. The CO background values are presented for informational purposes only since Boston is officially designated non-attainment for this pollutant.

The second highest 24-hour and highest annual TSP concentrations of 118 and 54 $\mu g/m^3$, respectively, monitored in Chelsea in 1984 and in East Boston in 1984 were also selected as background values.

It should be noted that these background levels were chosen without regard to the possible influence of existing pollutant emissions at Deer Island. Therefore, the background levels may be higher than what is truly indicative of the ambient concentrations caused by other sources.

8.1.3 MODELING

The air quality impacts of the fossil-fueled equipment for each phase of the project are estimated using the EPA Industrial Source Complex Short Term (ISCST) model. Refined modeling, incorporating five years (1981-1985) of Boston meteorological data, is performed for the 1988-1994 time period while ISCST in the screening mode for short-term impacts and the Industrial Source Complex Long-Term (ISCLT) model for annual average impacts are utilized to estimate impacts for the 1995-2020 time period. These computer models are executed for each piece of power-generating equipment, assuming full-load operation, to obtain estimates of the maximum impacts of the individual equipment operation. The air quality impact of each project phase is then determined by summing the predicted concentrations to obtain the maximum impact for those combinations of equipment needed to supply the power demand for each project phase. Maximum predicted air quality impacts are determined for NO_2 (1-hour and annual average), SO_2 (3- and 24-hour and annual average), CO (1- and 8-hour) and TSP (24-hour and annual average). For the 1995-2020 time period impacts, the 3-, 8-, and 24-hour concentrations are estimated from the 1-hour concentrations calculated by ISCST using the correction factors from the EPA "Guidelines for Air Quality Maintenance Planning and Analysis," Volume 10.

For modeling purposes, all Nordberg diesel emissions were assumed to originate from the center of the pump house, and the Enterprise diesel and Cleaver Brooks boiler emissions were assumed to emanate from the center of the building housing this equipment. The location of the Delaval diesel emissions for modeling purposes was estimated based on the proposed siting of these diesels. Likewise, the location of the gas turbine emissions is estimated based on the latest preferred siting of the new power station for Alternative 3B.

It should also be noted that the terrain elevations associated with the Deer Island drumlin and the proposed berm around the island were utilized in the model runs, but that public access to these areas was assumed to be restricted. Therefore, the maximum impacts resulting from this analysis are assumed to occur off the island or beyond security areas.

ISCST and ISCLT modeling assumptions are as follows:

- rural mode
- buoyancy-induced dispersion
- building downwash for diesels and boilers only
- gradual plume rise for diesels and boilers only
- no stack tip downwash for diesels and boilers only
- receptor elevations used
- air temperature - A:288° K, B:288° K, C:288° K, D:284° K, E:280° K, F:280° K (ISCLT); 284° K (ISCST)
- mixing heights - A:1200 m, B-D:800 m (ISCLT); 5000 m (ISCST)
- 1981-1985 Boston surface/Portland upper air meteorological data
- downwind distances - 100-1,000 m:100 m increments
1,000-3,000 m:200 m increments
3,000-5,000 m:500 m increments
- directions - 10° sectors

The meteorological conditions used in the ISCST runs in the screening mode are the same conditions used in the PTPLU screening model. These conditions are considered for all 10-degree wind direction sectors utilized in the model receptor grid.

The meteorological data for ISCLT modeling consist of a joint frequency distribution of wind speed, wind direction, and stability class based on 12 years (1970-1981) of Boston (Logan Airport) data. Assumed air temperatures and mixing heights are chosen based on the recommendation of the ISC User's Guide.

In addition to the model runs, a cavity analysis was performed in accordance with the procedures of Appendix C to the Regional Workshops on Air Quality Modeling. The results of that analysis demonstrated that the diesel and boiler emissions would be entrained into the building cavity, but that the building cavity did not extend beyond the plant boundary.

8.1.4 RESULTS AND CONCLUSIONS

The changes in air quality impacts for the power and pump stations for each phase for Alternatives 1, 3A and 3B are shown in Table H-25. This table indicates that for all time periods except 1990-1994, all alternatives would improve air quality in the area for all pollutants relative to existing emissions. For the 1990-1994 time period, Table H-25 indicates that annual SO_2 and NO_2 concentrations would increase slightly. In any event, the preliminary indication is that these alternatives would meet ambient air quality standards, including the DEQE 1-hour NO_2 policy. Since the 1990-1994 period is the only one in which NO_x emissions increase more than 250 tons/year (see Table H-24), the DEQE NO_2 policy of not exceeding 320 $\mu g/m^3$, including background, or not increasing the hourly impact by more than 32 $\mu g/m^3$ would apply. Since Table H-25 indicates a decrease in the hourly NO_2 concentration from the baseline to 1990, this policy is not expected to be violated.

The reason for the improvements in air quality resulting from the added generating capacity can be seen in Table H-26, which shows the air quality impact of the individual generating equipment. This table indicates that the new equipment (6,000-kw diesel generators and gas turbines) is capable of generating much more power with a smaller air quality impact than the existing equipment. For the 6,000-kw diesel generators, the smaller impact is related to lower pollutant-emission rates and the higher plume rise associated with the larger volumetric flow and higher exhaust temperature. The gas-turbine impacts are much smaller per kilowatt than the diesels, mainly because of the much smaller pollutant emission rates associated with the use of distillate and emission controls (water injection) as well as the greater stack height. Thus, replacing existing equipment with new generating equipment as much as possible results, for the most part, in improved air quality.

In regard to the non-attainment issue for CO and ozone, it was stated earlier that an increase in CO emissions of 100 tons/year or more or an increase in VOC emissions of 40 tons/year or more would require compliance with 310 CMR 7.00, Appendix A. Table H-24 indicates that CO and VOC emissions are expected to decrease for all projected phases and alternatives. Therefore, the application of the requirements of 310 CMR 7.00, Appendix A, to CO and VOC emissions would not be required.

TABLE H-25

CHANGES IN AIR QUALITY CONCENTRATIONS ($\mu g/m^3$) OF ALTERNATIVES 1, 3A AND 3B COMPARED TO EXISTING IMPACTS

	NO_x		SO_2			CO		TSP	
Year	1-hr	Annual	3-hr	24-hr	Annual	1-hr	8-hr	24-hr	Annual
Baseline	0	0	0	0	0	0	0	0	0
1988-1989	-245	-22	-10	-5	-2	-122	-120	-22	-3
1990-1994	-245	-7	-10	-5	+1	-122	-120	-22	0.2
1995-1998									
Altern. 3A	-1,543	-30	-72	-40	-3	-493	-330	-67	-3
Altern. 3B	-1,576	-30	-94	-40	-3	-503	-337	-67	-3
1999-2020									
Altern. 3A	-1,543	-30	-72	-40	-3	-493	-330	-67	-3
Altern. 3B	-1,576	-27	-94	-40	-1	-503	-337	-67	-3

TABLE H-26
ESTIMATED AIR QUALITY IMPACTS OF INDIVIDUAL EQUIPMENT

	Maximum Pollutant Concentrations (μg/m3)								
	SO_2			NO_2		CO			TSP
Year/Equipment	3hr	24hr	Ann.	1hr	Ann.	1hr	8hr	24hr	Ann.
Baseline									
Nordbergs (4)	127.4	46.7	1.9	1,568.0	21.5	407.7	278.6	51.9	2.2
Enterprises (2)	34.3	14.8	1.0	500.3	11.3	130.1	77.6	16.4	1.1
Boilers (3)	40.4	203.	0.6	58.5	0.7	5.0	3.7	3.1	0.1
Total	202.1	81.8	3.5	2,126.8	33.5	542.8	359.9	71.4	3.4
1988-1989									
Nordberg (1)	28.7	11.5	<0.1	392.8	0.2	100.0	69.7	13.0	<0.1
Enterprises (4)	77.0	33.1	<0.1	971.4	0.4	250.2	155.2	32.9	<0.1
Delaval (1)	42.3	17.4	0.9	460.8	9.9	22.3	11.8	0.4	<0.1
Boilers (3)	44.4	15.1	0.6	57.2	0.6	48.4	3.7	3.1	0.1
Total	192.4	77.1	1.5	1,882.2	11.1	420.9	240.4	49.4	0.1
1990-1994									
Nordberg (1)	28.7	11.5	<0.1	392.8	0.2	100.0	69.7	13.0	<0.1
Enterprises (4)	77.0	33.1	2.8	971.4	30.7	250.2	155.2	32.9	3.1
Delaval (1)	42.3	17.4	0.9	460.8	4.8	22.3	11.8	0.4	<0.1
Boilers (3)	44.4	15.1	0.6	57.2	0.7	48.4	3.7	3.1	0.1
Total	192.4	77.1	4.3	1,882.2	36.4	420.9	240.4	49.4	3.2
1995-1998									
Alternative 3A									
Delaval (1)	42.3	17.4	0.3	460.8	2.4	24.5	12.8	0.4	<0.1
Gas Turbines (2)	43.8	19.5	<0.1	65.4	<0.1	20.3	14.2	1.4	<0.1
Boilers (3)	44.4	15.1	0.6	57.2	0.7	5.2	3.2	3.1	0.1
Total	130.5	52.0	0.9	583.4	3.1	50.0	30.2	4.9	0.1
Alternative 3B									
Delaval (1)	42.3	17.4	0.3	460.8	2.4	24.5	12.8	0.4	0.1
Gas Turbines (1)	21.9	9.8	<0.1	32.7	<0.1	10.2	7.1	0.7	<0.1
Boilers (3)	44.4	15.1	0.6	57.2	0.7	5.2	3.2	3.1	0.1
Total	108.6	42.3	0.9	550.7	3.1	39.9	23.1	4.2	0.1
1995-2020									
Alternative 3A									
Delaval (1)	42.3	17.4	0.3	460.8	2.4	24.5	12.8	0.4	<0.1
Gas Turbines (2)	43.8	19.5	<0.1	65.4	<0.1	20.3	14.2	1.4	<0.1
Boilers (3)	44.4	15.1	0.6	57.2	0.7	5.2	3.2	3.1	0.1
Total	130.5	52.0	0.9	583.4	3.1	50.0	30.2	4.9	0.1
1995-1998									
Alternative 3B									
Delaval (1)	42.3	17.4	1.7	460.8	6.3	24.5	12.8	0.4	<0.1
Gas Turbines (1)	21.9	9.8	<0.1	32.7	<0.1	10.2	7.1	0.7	<0.1
Boilers (3)	44.4	15.1	0.5	57.2	0.7	5.2	3.2	3.1	0.1
Total	108.6	42.3	2.2	550.7	7.0	39.9	23.1	4.2	0.1

In regard to the application of the PSD requirements to this project, Table H-24 indicates NO_x and SO_2 emissions increases of 606 and 88 tons per year, respectively, in the 1990 to 1994 period as well as SO_2 emissions increases of as much as 123 tons/year in the 1999-2020 period. Since these increases are larger than the "significant" increase definition given in Table H-20 for these pollutants, compliance with PSD SO_2 and TSP increment consumption would apply to these phases of the project. However, as indicated in Table H-25, the only increase in the annual SO_2 concentration in the 1990-1994 phase is very small compared to the Class II increments shown in Table H-20. Although the available portion of the increment is not known at this time, it seems unlikely that PSD increments would impose constraints on the project.

8.2 NOISE EMISSIONS

The diesel engines and combustion turbines are expected to be the largest and most difficult-to-control sources of on-site operational noise. The primary noise sources of the diesel are the exhaust and the casing. Air intake is also a significant contributor. These engines would have to be enclosed and would require exhaust silencers, which provide the maximum available silencing. The primary sources of noise for the gas turbines are the compressor intake, the combustion exhaust, and auxiliary equipment. The gas turbines would also require silencing measures resulting in state-of-the-art reduction levels. The total sound level from both types of equipment with commercially available silencing is of the same order of magnitude. It should be noted that the preliminary costs developed in Section 7 include an allowance for enclosures and intake and exhaust silencers, which are commercially available and are typically provided for the diesels and gas turbines. A more refined analysis to be performed under facilities planning activities is required for further definition of equipment selection.

As part of the Deer Island Secondary Treatment Facilities Plan, activities are currently underway to characterize ambient noise levels at Deer Island and to develop evaluation criteria, including numeric noise limits, to be used on the project. MWRA is committed to complying with all of the legal standards of both the City of Boston and the DEQE and has further set a goal of going beyond legal compliance and providing the highest is achievable levels of noise control. A detailed noise analysis is contained in Section 11.4.4 of Volume III.

Nevertheless, based on a review of previous reports addressing Deer Island noise concerns and the preliminary types and amounts of power generation equipment for the two alternatives, noise level concerns are not expected to constrain the selection of either of the alternatives evaluated. It is more a case of selecting the appropriate noise control measures to be incorporated into each alternative so that any resulting noise impacts are minimized.

9.0 THIRD-PARTY INTEREST

In accordance with Work package 60A, third-party interest in developing, owning, and operating the power plant portion of the Deer Island wastewater treatment facility was solicited. Swift River/Hafslund Company (SR/H) expressed interest in pursuing involvement in the project.

SR/H outlined its capabilities and proposed approach relative to all phases of the power plant project development and operation. SR/H's approach and scope of responsibilities would be as follows:

1. Fuel and Power Sales Contracts - Negotiate fuel, electricity, and transmission contracts.

2. Regulatory Permitting - Assess permitting requirements and obtain permits, using consultants as required.

3. Project Financing - Evaluate and negotiate construction and long-term financing.

4. Project Design and Construction

    a. Site Review - Assess support or opposition by community and regulatory agencies. Determine fuel and water availability and environmental impact.

    b. Specification Preparation - Develop design basis for preparation of project specifications by a consulting engineer.

    c. Selection of Construction Contractor and Project Engineer - Qualify and select, via competitive bidding, a construction contractor and project engineer.

    d. Equipment Procurement and Fabrication - Oversee and maintain final approval of this effort, which is the direct responsibility of the construction contractor and project engineer.

    e. Performance Testing - Witness, evaluate, and accept performance tests.

5. Project Operations - Under a separate fixed-price contract hire, train, supervise, and pay operating personnel; operate and monitor plant; perform routine preventive maintenance; prepare operating records, reports, and annual maintenance budgets.

6. Project Insurance - Define and administer the appropriate insurance obligations.

Since third-party interest exists, MWRA should consider issuing an RFP for an on-site power plant owned and operated by a third party.

10.0 CONCLUSIONS AND RECOMMENDATIONS

10.1 CONCLUSIONS

10.1.1 OFF-SITE POWER SUPPLY

Differences in present worth costs between the single and the dual off-site power supply alternatives are relatively small. While the single-supply alternative might be optimized by phased installation of the on-site power plant resulting in a lower present worth cost than the lowest-cost dual-supply alternative considered, the difference is small considering the significant flexibility offered by the dual off-site supply approach in dealing with future loads, fuel prices, and electric rates. The dual off-site alternative is recommended.

10.1.2 ADDITIONAL ON-SITE GENERATION

Even with two off-site sources of power, on-site generation has value in that it reduces demand and peak energy charges from BECo. A large, two-unit station would be required with a single off-site supply to cover critical loads in the event of a power failure coincident with a generating unit being out of service. In the dual off-site supply case, economics indicate that a unit in the 25-MW size range is appropriate. This unit, in conjunction with existing and committed capacity, can generate most of the facility's normal loads during peak electric rate periods and could provide a major portion of critical loads, even during a massive blackout condition that might affect both off-site supplies.

10.1.3 IMPACT OF DIGESTERS

The use of digesters in the treatment process, with their associated heating loads and gas production, results in a reduction of present worth energy costs, regardless of the strategy selected. Most of the gas can be used in the already committed dual-fuel diesel engines, and the heat load can be met by waste heat from those engines. Consequently, the choice of power supply strategy is not affected by the existence or nonexistence of the digesters. Differential present worth costs among the strategies evaluated are similar in either situation.

Based on predicted digester gas quantities from Table H-13, sufficient digester gas will be available in 1995 to generate 5,800 kw if used as produced and 13,900 kw if 16-hour storage is provided for peak shaving. In 1999 these needs will increase to 11,000 kw and 25,000 kw, respectively.

10.1.4 SENSITIVITY OF RESULTS

Fuel price

If fuel price were to change dramatically relative to power cost and capital costs, the lowest present worth strategy would be different. An increase from \$3.75/MBtu to \$6.00/MBtu would

make the dual off-site supply/no new on-site generation alternative the preferred choice. A decrease to $2.00/MBtu would make the single off-site supply, large combined-cycle plant alternative the preferred choice.

Discount rate

If the effective cost of capital to the MWRA is lower than 8.625 percent (real), this would favor a larger combined cycle-plant, with or without a second off-site supply. A substantially higher cost of capital would tend to favor the dual off-site supply/no new on-site generation alternative.

10.2 RECOMMENDATIONS

Based on the energy projections provided in Section 4.0, the economic analysis developed in Section 7.0, and the environmental considerations discussed in Section 8.0, the following recommendations are made:

1. Begin work immediately to install power transmission line(s) interconnecting the Deer Island facilities to BECo's power system grid. To meet the required in-service dates, formal application should begin immediately. The wheeling of power from BECo to Deer Island through Mass Electric's system grid for immediate power should also start as soon as possible.

2. Provide duplicate power transmission lines and some amount of additional on-site capacity to meet reliability design criteria and be in accordance with economic evaluation results.

3. Add 25,700 kw of on-site power- and heat-generating capacity capable of burning No. 2 fuel oil and natural gas in addition to that already committed by the Fast-Track Improvements Program. Continue to investigate the availability and cost of an off-island source of natural gas.

4. Consider retaining a private party, with specialized expertise in the operation and maintenance of power- and heat-generating systems, to operate and maintain all on-site power- and heat-generating equipment. In addition, the possibility of private ownership of this on-site capacity should also be assessed.

It is further recommended that MWRA re-evaluate this study prior to authorizing the installation of the combined cycle power plant and the second 115 kv permanent feeder from Chelsea. The results of this study are based on current economics, estimated load projections, and the ability of BECo to provide long-term reliable power from two separate sources. If in the future, additional on-site capacity is found to be desirable, an evaluation of air quality and noise impacts should be performed.

10.3 IMPLEMENTATION PLAN

The recommendation to proceed to establish an off-site power supply for Deer Island can best be implemented by taking steps now to initiate the necessary applications for an off-site electrical power supply. The application for service will also begin the process of negotiating an agreement with the utilities. The process must be started now to ensure a comprehensive and timely plan for providing power to Deer Island during construction and operation of the facilities.

The following efforts should be implemented in the near future:

1. MWRA should initiate immediate formal application with Boston Edison for providing both interim and permanent electric power to Deer Island in a timely and environmentally acceptable manner.

2. The process of engineering, design, environmental permitting, construction, start-up, and test of the recommended power-generating capacity additions should be initiated.

APPENDIX H - NUT ISLAND

1.0 SUMMARY

A preliminary evaluation was conducted to determine the energy requirements for the new Nut Island Headworks facilities.

Both the electric power and the steam heating demands at the new headworks facility will be significantly less than the present demands at the existing Nut Island Primary Treatment Plant due to the following:

- o Heating requirements associated with the existing anaerobic digesters will be eliminated; and

- o Electric power demand associated with the existing primary treatment plant operations will be eliminated.

The peak electric demand at the new headworks facility is estimated to be 400 kw. The existing off-site power supply from Massachusetts Electric Company is capable of meeting all future electric power requirements at Nut Island. The offsite power supply will feed two new 500 kVA (400 kw) transformers which will step down the voltage for use at the new headworks facility. Backup power will be provided by one new onsite 400 kw diesel generator.

Peak steam demand for building heating is estimated to be approximately 4400 lb/hr. In order to meet this demand and provide adequate redundancy, two nominal 6000 lb/hr oil-fired heating boilers will be installed.

Two nominal 15,000 gallon fuel oil storage tanks will also be provided. Each tank is sized to provide storage capacity for operating a steam boiler and the diesel generator for one week at the peak heating and electrical demands. During the peak heating period, one fuel oil truck delivery will be required every one to two weeks.

2.0 EXISTING TREATMENT PLANT ENERGY SUPPLY FACILITIES

Energy supply facilities at Nut Island consist of off-site electric power from Massachusetts Electric Company (MECo), on-site diesel electric generators, diesel mechanical drives, and steam boilers. The MECo tie-line was installed in 1986 and currently supplies all electric power requirements to Nut Island.

The MECo tie-line is a 13,800 volt single source of power. It feeds two off-site transformers which reduce the voltage and feed the plant load centers. The transformers have a maximum continuous rating of 750 kVA (600 kw) and 2000 kVA (1600 kw), respectively. The tie-line and transformers are in good condition and supply all electric power required at the plant.

Four on-site diesel electric generators supplied electric power to the plant prior to the installation of the MECo tie-line in 1986. Since 1986, the diesel generators have provided back-up service. Three generators are rated at 575 kw and burn methane produced on-site, or No. 2 fuel oil as a backup. One generator is rated at 450 kw and burns No. 2 fuel oil. These diesels first began service in 1952, are aging, and spare parts availability is becoming a problem. The diesels are currently undergoing a major overhaul which should be completed in 1988.

Two 100 percent capacity diesels mechanically drive blowers which provide air for the treatment plant aeration process. Each diesel is rated at 213 horsepower (hp) and burns No. 2 fuel oil. These diesels were installed in 1952 and are aged. However, plant operating personnel anticipate no problems keeping them in service until 1995 when the treatment plant will be decommissioned.

Steam is generated at 15 psig for building heating and digestor process heating requirements. Three boilers are currently available for service. Two Kewanee boilers, each rated at 6500 lb/hr, were installed in 1983. One Cleaver Brooks boiler, rated at 21,500 lb/hr, was installed in 1982. The Kewanee boilers carry the bulk of the load, as the Cleaver Brooks boiler has been downrated from 150 psig, and consequently is less efficient. All three boilers, which are in excellent operating condition, are fired by methane produced on-site, with No. 2 fuel oil used as back-up.

The following is a listing of the energy supply equipment currently at Nut Island:

Massachusetts Electric Power Company Transformers

No. 1

Manufacturer	General Electric
Voltage	13,800/480/280
Max. Cont. Rating	750 kVA
Peak Rating	1115 kVA (with fans)

No. 2

Manufacturer	General Electric
Voltage	13,800/2400
Max. Cont. Rating	2000 kVA
Peak Rating	3000 kVA (with fans)

Diesel Electric Generators

No. 1

Rating	719 kVA at .8 Power Factor (pf)
kW	575
Voltage	2400
Amps	173
Rpm	360
Fuel	Methane No. 2 fuel oil

No. 2

Rating	719 kVA at .8 pf
kW	575
Voltage	2400
Amps	173
Rpm	360
Fuel	Methane No. 2 fuel oil

No. 3

Rating	719 kVA at .8 pf
kW	575
Voltage	2400
Amps	173
Rpm	360
Fuel	Methane No. 2 fuel oil

No. 6

Rating	562 kVA at .8 pf
kW	450
Voltage	2400
Amps	135
Fuel	No. 2 fuel oil

Diesel Blower Drives

No. 4	
HP	213
Fuel	No. 2 fuel oil
No. 5	
HP	213
Fuel	No. 2 fuel oil

Boilers

No. 1

Manufacturer	Kewanee
Pressure	15 psig
Temperature	Saturated
MCR	6500 lb/hr
Fuel	Methane No. 2 fuel oil

No. 2

Manufacturer	Kewanee
Pressure	15 psig
Temperature	Saturated
MCR	6500 lb/hr
Fuel	Methane No. 2 fuel oil

No. 3

Manufacturer	Cleaver Brooks
Pressure	150 psig (design, downrated to 15 psig operating)
Temperature	Saturated
MCR	21,500 lb/hr
Fuel	Methane No. 2 fuel oil

3.0 EXISTING AND FUTURE ENERGY DEMANDS

Energy demands at Nut Island have changed, and will continue to change with time. See Tables H-27 and H-28.

Pre-1986

Prior to the installation of the MECo tie line in 1986, all energy demands were supplied by on-site generators. A review of recent electric power consumption records indicates an annual average demand of approximately 900 kw and a peak demand of 1500 kw.

The four on-site generators have a combined capacity of 2175 kw.

One direct drive diesel driven blower is required to operate continuously to supply air for the treatment plant aeration process. This demand is 213 HP. Peak demand could double for a short period of time when switching from one blower to the other.

Steam demand for building heating and digestor process heating has been supplied by the three steam boilers. For building heating, the steam demand averages 600 lb/hr, ranging from essentially zero in the summer to a peak of 2650 lb/hr in January. The steam demand for digester heating averages 2750 lb/hr, and has a peak of approximately 4550 lb/hr.

1986-1992

In 1986, the MECo tie-line was installed. The average and peak electrical demands of 900 kw and 1500 kw are unchanged from pre-1986. However, nearly all electrical power is now purchased from MECo. The four diesel electric generators provide backup service in the event of a tie-line failure.

The energy demands for the blowers, building heating, and digester process heating are the same as pre-1986.

1992-1995

Construction of the new headworks facility will begin in 1992 and be completed in 1995. During this time period, energy demands at Nut Island will change.

Electrical power demand will increase due to construction loads and steam demand will decrease due to the elimination of the digesters.

Construction power requirements are estimated to average 100 kw with a peak demand of 200 kw. Treatment plant demand should not change. Therefore, the estimated total electrical power demand at Nut Island between 1992 and 1995 is estimated to average 1000 kw and peak at 1600 kw. The existing MECo tie-line and transformers are capable of meeting this demand.

TABLE H-27

PRELIMINARY ELECTRICAL AND MECHANICAL POWER DEMANDS FOR NUT ISLAND

Year	Description of Power Demand	Electrical Power Demand Average (kw)	Electrical Power Demand Peak (kw)	Mechanical Power Demand Average (HP)	Mechanical Power Demand Peak (HP)
Present - 1992	Existing Treatment Plant Operation	900	1500	213	426
1992-1995	Exisitng Treatment Plant Operation plus Construction Power for Headworks Facility	1000	1600	213	426
1995	Existing Treatment Plant and Headworks Facility Operation	1200	1900	213	426
1995-2020	Headworks Facility Operation	300	400	0	0

TABLE H-28

PRELIMINARY STEAM DEMANDS FOR BUILDING HEATING AT NUT ISLAND

Year	Description of Steam Demand	Steam Demand Average (lb/hr)	Steam Demand Peak (lb/hr)
Present-1992	Existing Treatment Plant Building Heating plus Digester Operation	3350	7200
1992-1995	Existing Treatment Plant Building Heating	600	2650
1995	Existing Treatment Plant and Headworks Facility Building Heating	2030	7050
1995-2020	Headworks Facility Building Heating	1430	4400

The energy demand for the blowers will remain unchanged.

The steam demand for the digesters will be eliminated. However, steam will continue to be required for building heating. It is estimated that the average and peak steam demand will be 600 lb/hr and 2650 lb/hr, respectively.

1995

Upon completion of construction, the new headworks facility will go through start-up in 1995. There will be a transition period of several months when it will be necessary to operate both the existing treatment plant and the new headworks facility.

The electrical, mechanical, and steam energy requirements for the treatment plant remain unchanged during the 1992-1995 time period but the construction load will be eliminated. However, the headworks facility will add additional electrical power and steam for building heating demands.

The Headworks Facility will require electrical power for process equipment, lighting, heating ventilation and air conditioning (HVAC), etc. The estimated average load is 300 kw, with a peak demand of 400 kw.

The new headworks facility is estimated to include 391,000 cubic feet of building volume which will require heating. This total volume includes the building, tunnels, grit chambers, and garage. Utilizing data provided by the American Society of Heating, Ventilating and Air Conditioning Engineers, the average and peak steam demand is estimated to be 1430 lb/hr and 4400 lb/hr, respectively. The estimated monthly heating loads are shown on Table H-29.

1995-2020

After start-up of the new headworks facility and decommissioning of the existing treatment plant, the energy demands at Nut Island should remain essentially constant between 1995 and 2020.

As previously discussed, average and peak electrical demand is estimated to be 300 kw and 400 kw respectively. The average and peak steam demand is estimated to be 1430 lb/hr and 4400 lb/hr.

TABLE H-29

HEAT LOAD PER MONTH
NUT ISLAND HEADWORKS FACILITY

1995-2020

Month	Degree Days	Heat Load (lb steam/mo)
January	1088	2,415,000
February	972	2,158,000
March	846	1,878,000
April	513	1,139,000
May	208	462,000
June	36	80,000
July	0	0
August	9	20,000
September	60	133,000
October	316	702,000
November	603	1,339,000
December	983	2,182,000
Annual Total	5634	12,508,000

4.0 RECOMMENDED HEADWORKS ENERGY SUPPLY FACILITIES

As shown in Table H-27, the peak electrical demand at the new headworks facility is 400 kW. This is significantly less than the existing treatment plant peak load of 1500 kW, which is presently supplied by the 13,800 volt MECo tie-line. Therefore, this existing tie-line is capable of supplying the long term power demand to Nut Island. It will supply two 500 kVA (400 kW) transformers which will step down the voltage and feed the facility load centers. In the event of a tie-line outage, back-up power will be provided by one 400 kW diesel electric generator.

As shown on Table H-28, the peak steam demand is estimated to be 4400 lb/hr. In order to meet this heating demand with adequate redundancy, it is recommended that two nominal 6000 lb/hr fire tube boiler producing 15 psig steam be installed.

The steam boilers and the diesel will be fueled by No. 2 fuel oil. Two nominal 15,000 gallon oil storage tanks will be provided. Each tank can supply fuel to the boilers and the diesel for one week at coincident peak steam and electric demands.

The total installed project cost of the two boilers, diesel electric generator, two storage tanks and all associated equipment, piping, and controls is estimated to be $500,000.

The existing 575 kW and 450 kW diesels at the Nut Island Treatment Plant are currently being overhauled. Also, the two 6500 lb/hr Kewanee boilers are in good condition. These units all closely match the future loads at the headworks facility. It may be desirable to retain and store one or more units, depending on its condition in 1995. An equipment survey to make this determination should be conducted at that time.

5.0 AIR QUALITY - NUT ISLAND

The first step in this air quality analysis consists of characterizing pollutant emissions and resulting air quality impacts associated with the existing equipment which consists of three 575-kw diesel engines, one 450-kw diesel generator and two 213 hp diesel engines operated as required to meet power demand, as well as three heating boilers. The pollutant emissions and air quality impacts associated with different modes of operation of the existing equipment as well as the addition of a new 400-kw diesel generator and two new boilers are then examined and compared with the emissions and impacts associated with existing operations on Nut Island.

The various combinations of diesels, and boilers that are utilized in each phase are shown in the Table H-30.

This preliminary air quality impact analysis is performed using an EPA screening level computer model along with estimates of pollutant emissions obtained from EPA publications. Information for the development of stack parameters needed for computer modeling is obtained from DEQE fuel-burning equipment registration forms (Form AP-1, DEQE 86) In some cases, stack parameters, such as exit velocity, are estimated using fuel use or heat-input data. In addition, estimates of background concentrations of the criteria pollutants on Nut Island are obtained from monitoring data published by the DEQE. The details of the analysis are described in the following subsections.

5.1 EMISSIONS CHARACTERISTICS

The emissions characteristics needed to model the air quality impact of each piece of equipment include stack height, inside stack diameter, exit velocity, exit temperature, and pollutant emission rate. This information is obtained for the diesel generators and engines as well as for the heating boilers from DEQE fuel-burning equipment registration forms (Form AP-1, DEQE 86) and from drawings of the Nut Island facility. The volumetric flow for the diesels and boilers is calculated based on the maximum firing rate for each unit and an assumed 40 lbs of flue gas generated per pound of fuel burned. The stack parameters for all equipment are given in Table H-31.

The emission rates of the criteria pollutants from all equipment, including nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), volatile organic compounds (VOC), and total suspended particulates (TSP), are estimated using EPA publication AP-42. The emissions estimates for the diesels and boilers assume no flue-gas controls. In estimating pollutant emission rates for predicting air quality impacts associated with 1-hour, 3-hour, 8-hour, and 24-hour emission rates, it was assumed that the diesels would operate at 100 percent capacity while the boilers are operated to provide the maximum possible amount of steam that could be used. The diesel emissions of SO_2 assume that use of 0.2 percent sulfur diesel fuel. The estimated pollutant emission rates from all equipment at full load are given in Table H-32.

Pollutant emissions rates for existing conditions (baseline) and future conditions based on annual average and peak usage conditions for each project phase are given in Table H-33. The

TABLE H-30

NUT ISLAND FOSSIL-FUEL EQUIPMENT INVENTORY

Period	575 kw Diesel Generator			213 hp Diesel Engine			450 kw Diesel Generator			400 kw Diesel Generator			Existing Boilers			New Boilers		
	Oper. (No.)	Stdby (No.)	ALF (%)	Oper. (No.)	Stdby (No.)	ALF (%)	Oper. (No.)	Stdby (No.)	ALF (%)	Oper. (No.)	Stdby (No.)	ALF (%)	Oper. (No.)	Stdby (No.)	ALF %	Oper. (No.)	Stdby (No.)	ALF %
Baseline	3	0	25	1	1	40	0	1	24	-	-	-	2	1	6	-	-	-
1987-1991	3	0	1	1	1	40	0	1	0	-	-	-	2	1	46	-	-	-
1992-1994	3	0	1	1	1	40	0	1	0	-	-	-	1	1	28	-	-	-
1995	3	0	1	1	1	40	0	1	0	1	0	1	1	1	28	1	1	46
1996-2020	-	-	-	-	-	-	-	-	-	1	0	1	-	-	-	1	1	46

Oper. = Operating
Stdby = Standby
ALF = Annual Load Factor

TABLE H-31

STACK PARAMETERS

Equipment	Stack height (m)	Stack diameter (m)	Exit velocity (m/sec)	Exit temperature (° K)
575 kw diesel engine	12.2	0.30	43.0	755
400 kw diesel generator	12.2	0.30	30.0	755
213 hp diesel engine	12.2	0.30	11.0	755
Existing heating boilers	15.2	1.5	1.6	422
New boilers	15.2	1.5	0.8	422

TABLE H-32

POLLUTANT EMISSION RATES FOR ALL OPERATING EQUIPMENT[1]

	Pollutant Emission Rate (lbs/hr)				
Equipment	NOx	SO_2	CO	TSP	VOC
575 kw diesel engine	20.0	1.2	5.2	2.0	0.5
400 kw diesel generator	13.9	0.8	3.6	1.4	0.4
213 hp diesel engine	5.0	0.3	1.3	0.5	0.1
Existing heating boilers	1.3	1.9	0.3	0.1	0.02
New boilers	1.2	1.7	0.3	0.1	0.02

(1) See Table H-30 for operating conditions.

TABLE H-33

POLLUTANT EMISSION RATES FOR PROJECT PHASES

Year	Pollutant Emission Rate				
	NOx	SO_2	CO	TSP	VOC
Baseline					
Ann. Avg. (a)	75	6	19	8	2
Peak (b)	66	6	17	7	2
1987-1991					
Ann. Avg.	14	5	4	1	0.3
Peak	66	6	17	7	2
1992-1994					
Ann. Avg.	12	2	3	1	0.3
Peak	66	6	17	7	2
1995					
Ann. Avg.	14	4	4	1	0.3
Peak	81	8	21	8	2
1996-2020					
Ann. Avg.	2	2	0.5	0.2	0.04
Peak	15	2	4	2	0.4

(a) Average emissions are measured in tons/yr.

(b) Peak emissions are measured in lbs/hr.

baseline emissions are preliminarily based on actual fuel usage for 1986 from Form AP-1, DEQE 86 while future emissions are based on an assumed diesel usage of 1 percent of the time since it is meant to be only a backup emergency diesel. Also, Table H-30 shows the combination of equipment assumed in estimating the emissions shown in Table H-33. Table H-33 indicates that annual emissions of all pollutants will decrease from the baseline case for all project phases, with a significant decrease in the 1996-2020 phase as the existing diesels and boilers are replaced by just one 400-kw diesel and two new boilers. The new diesel will be used only on an emergency basis while only one boiler could possibly be used at any given time. Short-term pollutant emission rates will essentially remain constant from the baseline case through the 1992-1994 period with a small increase in emission rates in 1995 as the new headworks is installed.

The predicted impacts of these emissions on ambient air quality are discussed below.

5.2 BACKGROUND AIR QUALITY

Background air quality concentrations are determined from the air quality monitoring data published by the Massachusetts DEQE. Wherever possible, data from the Long Island or Quincy monitoring station are used to determine background concentrations. For averaging times less than annual average, the second highest monitored value from the latest three years of data was chosen as background. The largest annual average value for the three most recent years of data was also chosen as background. If data from Long Island or Quincy were not available for a given pollutant, the highest monitored values from nearby stations (Deer Island or East Boston) for the three most recent years of data were chosen.

Background NO_x concentrations at Nut Island are estimated to be 61 $\mu g/m^3$ on an annual basis. This concentration is based on a 1984 monitored value of 61 $\mu g/m^3$ at East Boston.

For SO_2, 3- and 24-hour concentrations of 236 $\mu g/m^3$ and 254 $\mu g/m^3$ were chosen as background levels for Nut Island. The highest 3- hour and 24-hour SO_2 concentrations were recorded at Long Island in 1984. The annual average SO_2 background concentration of 23 $\mu g/m^3$ was recorded at Long Island in 1981.

For CO, 1-hour and 8-hour concentrations of 29,000 $\mu g/m^3$ and 10,000 $\mu g/m^3$ were chosen for background at Nut Island, based on 1985 and 1983 monitoring results, respectively, in East Boston. The CO background values are presented for informational purposes only since Boston is officially designated non-attainment for this pollutant.

The highest monitored 24-hour and annual TSP concentrations of 133 and 41 $\mu g/m^3$, respectively, in Quincy in 1983 were also selected as background values.

5.3 MODELING

The air quality impacts of the fossil-fueled equipment for each phase of the project are estimated using the EPA Industrial Source Complex Short Term (ISCST) model in the screening

mode. This computer model is executed for each piece of power-generating equipment, assuming full-load operation for the diesels and the highest possible steam production load for the boilers, to obtain estimates of the maximum impacts of the individual equipment operation. The air quality impact of each project phase is then determined by summing the predicted concentrations to obtain the maximum impact for those combinations of equipment needed to supply the power and steam demand for each project phase. Maximum predicted air quality impacts are determined for NO_x (1-hour and annual average), SO_2 (3- and 24-hour and annual average), CO (1- and 8-hour) and TSP (24-hour and annual average). The 3-, 8-, and 24-hour concentrations are estimated from the 1-hour concentrations calculated by ISCST using the correction factors from the EPA "Guidelines for Air Quality Maintenance Planning and Analysis," Volume 10. Annual average impacts were estimated from the 1-hour impacts using a conservative factor of 0.1.

For modeling purposes, all diesel emissions were assumed to originate from the center of the engine room and the boiler emissions were assumed to emanate from the center of the administration building.

ISCST modeling assumptions are as follows:

- rural mode
- buoyancy-induced dispersion
- building downwash
- gradual plume rise
- no stack tip downwash
- receptor elevations used
- air temperature - 284° K
- mixing heights - 5000 m

- downwind distances - 100-1,000 m:100 m increments; 1,000-3,000 m:200 m increments; 3,000-5,000 m:500 m increments
- directions - 10° sectors

The meteorological conditions used in the ISCST runs in the screening mode are the same conditions used in the PTPLU screening model. These conditions are considered for all 10-degree wind direction sectors utilized in the model receptor grid.

5.4 RESULTS AND CONCLUSIONS

The air quality impacts of the Nut Island facility for each phase, including estimated background pollutant concentrations, are shown in Table H-34. Changes in air quality impacts for each phase are shown in Table H-35. These tables indicate that the equipment configuration for all but one phase would result in constant or improved air quality in the area for all pollutants relative to existing emissions. Only the 1995 phase with the addition of the headworks will result in some small increases in short-term impacts

TABLE H-34

AIR QUALITY IMPACTS OF PROJECT PHASES

Year	Maximum pollutant concentrations (ug/m^3)(a)								
	SO_2			NO_2		CO		TSP	
	3-hr	24-hr	Ann.	1-hr	Ann.	1-hr	8-hr	24-hr	Ann.
Baseline									
Predicted	107	47	3	1,242	41	322	225	49	4
Background	236	254	23	333	61	29,000	10,000	133	41
Total	343	301	26	1,575	102	29,322	10,225	182	45
Standard	1,300	365	80	320	100	40,000	10,000	260	75
PSD increment (a)	512	91	20	--	--	--	--	37	19
1987-1991									
Predicted	107	47	3	1,242	10	322	225	49	1
Background	236	254	23	333	61	29,000	10,000	133	41
Total	343	301	26	1,575	71	29,322	10,225	182	42
Standard	1,300	365	80	320	100	40,000	10,000	260	75
PSD increment (a)	512	91	20	--	--	--	--	37	19
1992-1994									
Predicted	92	41	3	1,231	10	319	223	49	0.9
Background	236	254	23	333	61	29,000	10,000	133	41
Total	328	295	26	1,564	71	29,319	10,223	182	42
Standard	1,300	365	80	320	100	40,000	10,000	260	75
PSD increment (a)	512	91	20	--	--	--	--	37	19
1995									
Predicted	120	53	4	1,252	11	325	227	50	1
Background	236	254	23	333	61	29,000	10,000	133	41
Total	356	307	80	320	72	29,325	10,227	183	42
Standard	1,300	365	80	320	100	40,000	10,001	260	75
PSD increment (a)	512	91	20	--	--	--	--	37	19
1996-2020									
Predicted	40	18	1	245	1	61	43	10	0.1
Background	236	254	23	333	61	29,000	10,000	133	41
Total	276	272	24	1,585	62	29,063	10,043	143	41
Standard	1,300	365	80	320	100	40,000	10,000	260	75
PSD increment (a)	512	91	20	--	--	--	--	37	19

TABLE H-35

CHANGES IN AIR QUALITY CONCENTRATIONS ($\mu g/m^3$) OF PROJECT PHASES COMPARED TO EXISTING IMPACTS

	NO_2		SO_2			CO		TSP	
Year	1-hr	Annual	3-hr	24-hr	Annual	1-hr	8-hr	24-hr	Annual
Baseline	0	0	0	0	0	0	0	0	0
1987-1991	0	-31	0	0	0	0	0	0	-3
1992-1994	-11	-31	-15	-6	0	-3	-2	0	-3
1995	+10	-30	+13	+6	+1	+3	+2	+1	-3
1995-2020	-997	-40	-67	-29	-2	-261	-182	-39	-4

as both the old and new equipment are utilized at this time. Otherwise, less dependence on the existing equipment and its eventual removal results in generally improving air quality. In any case, the analysis indicates that all ambient air quality standards would be met.

In regard to the non-attainment issue for CO and ozone, it was stated earlier that an increase in CO emissions of 100 tons/year or more or an increase in VOC emissions of 40 tons/year or more would require compliance with 310 CMR 7.00, Appendix A. Table H-33 indicates that CO and VOC emissions both decrease for all project phases. Therefore, the application of the requirements of 310 CMR 7.00, Appendix A, to CO and VOC emissions would not be required.

In regard to the application of the federally-mandated Prevention of Significant Deterioration (PSD) requirements to this project, it has been shown that annual pollutant emissions will decrease in all cases from the baseline case. Therefore, PSD requirements do not apply to this project.

ATTACHMENT A

TABLE A-1
ECONOMIC ASSUMPTIONS -- NO DIGESTERS

CONSTANTS:

Discount rate (real)			8.625%	
Base year for prices			1986	
Base year for present worth			1990	
Price of fuel, $/MBtu			$3.75	
Price of electricity:				
Demand, $/kW-yr			$117	
Facilities, $/kW-yr			$0	
Energy, $/kWh		hrs		
On-peak		3389	0.02957	
Off-peak		5371	0.00626	
Fuel adjustment		8760	0.02047	
Diesels:	Heat rate		Ht recovery	O&M Cost
	9200 Btu/kWh		2381 Btu/kWh	$20 /kW-yr
New feeders:	Capacity		Capital cost	
A	70 MW		$9,500 x1000	
B	70		$10,600 x1000	
New unit data:	Heat rate		Capital cost	O&M Cost
Combined cycle	0 Btu/kWh		$0 /kW	$40 /kW-yr
	0.0 MW		0.0353 kWh/lb	
Unit availablities, h/yr			7500 85.62%	
Digester gas on-peak availablity			38.69%	

Electric load profile:

Hours	Load	Energy	Cum Energy	Cum Hours	dY/dX
0	0.0	0.0000	0.0000	8760	1.0000
0	0.1	0.0000	0.1000	8760	1.0000
0	0.2	0.0000	0.2000	8760	1.0000
10	0.3	0.0003	0.3000	8760	0.9989
430	0.4	0.0196	0.3999	8750	0.9498
1750	0.5	0.0999	0.4949	8320	0.7500
6400	0.6	0.4384	0.5699	6570	0.0194
160	0.7	0.0128	0.5718	170	0.0011
5	0.8	0.0005	0.5719	10	0.0006
4	0.9	0.0004	0.5720	5	0.0001
1	1.0	0.0001	0.5720	1	0.0000
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8760		0.5720			

TABLE A-1
ECONOMIC ASSUMPTIONS -- NO DIGESTERS
(Continued)

Period definitions:						
First year	1986	1988	1991	1993	1995	1999
Last year	1987	1990	1992	1994	1998	2020
Present worth						
Operating cost	0.000	0.000	1.768	1.498	2.346	5.012
Capital cost	0.000	0.000	1.000	0.848	0.718	0.516
Electric demand, MW:						
Basic usage	0.65	0.65	0.65	2.65	2.65	2.65
Influent pumping	1.50	8.70	8.70	8.70	20.80	20.80
Construction	0.00	0.00	15.00	15.00	3.00	0.00
Nut Island flow	0.00	0.00	0.00	0.00	5.60	5.60
Air emmissions	0.00	0.00	0.00	0.00	1.25	1.50
Disinfection	0.00	0.00	0.00	0.00	0.00	0.00
Secondary trt	0.00	0.00	0.00	0.00	0.00	19.40
Primary trt	0.00	0.00	0.00	0.00	7.90	7.90
Dewatering	0.00	0.00	3.00	3.00	3.00	5.00
Annual peak	2.15	9.35	27.35	29.35	44.20	62.85
Engine driven pumps equivalent kW	12.00	6.00	6.00	6.00	0.00	0.00
Total equiv MW	14.15	15.35	33.35	35.35	44.20	62.85
Critical load, MW	14.15	15.35	30.35	32.35	41.20	44.45

TABLE A-1
ECONOMIC ASSUMPTIONS -- NO DIGESTERS
(Continued)

First year	1986	1988	1991	1993	1995	1999
Last year	1987	1990	1992	1994	1998	2020
Electric energy, MWh/yr:						
LF = 57.20%	10773	46849	137040	147061	221469	314916
Engine driven pump energy, equiv MWh/yr:						
	60127	30064	30064	30064	0	0
Total equivalent energy, MWh/yr:						
	70900	76913	167104	177125	221469	314916
Committed capacity						
Existing diesels						
1.5 MW	8	4	4	4	0	0
0.7 MW	5	5	5	5	0	0
0.3 MW	2	0	0	0	0	0
New Dual fuel						
6.0 MW	0	2	2	2	2	2
Total MW	16.1	21.5	21.5	21.5	12.0	12.0
Largest unit	1.5	6.0	6.0	6.0	6.0	6.0
Secure MW	14.6	15.5	15.5	15.5	6.0	6.0
Steam requirements, MBtu/h avg						
Digesters	0.0	0.0	0.0	0.0	0.0	0.0
Blgs & tunnels	9.8	9.8	9.8	9.8	9.8	9.8
Digester gas output:						
Average, MBtu/h	0.0	0.0	0.0	0.0	0.0	0.0
Annual, MBtu/yr	0	0	0	0	0	0
Capacity required, MW	0.0	0.0	17.9	19.9	38.2	56.9

TABLE A-2

ALTERNATIVE 1 - NO NEW GENERATION, DUAL UTILITY FEEDER, NO DIGESTERS

First year	1986	1988	1991	1993	1995	1999
Last year	1987	1990	1992	1994	1998	2020
New capacity, units						
70 MW feeder	0	0	2	2	2	2
0.0 MW C.C.	0	0	0	0	0	0
Cumulative MW						
Committed	16.1	21.5	21.5	21.5	12.0	12.0
Feeder	0.0	0.0	140.0	140.0	140.0	140.0
C.C.	0.0	0.0	0.0	0.0	0.0	0.0
Total	16.1	21.5	161.5	161.5	152.0	152.0
Largest unit	1.5	6.0	70.0	70.0	70.0	70.0
Secure MW	14.6	15.5	91.5	91.5	82.0	82.0
Capital costs, 1000$						
Feeder	$0	$0	$20,100	$0	$0	$0
C.C.	$0	$0	$0	$0	$0	$0
Total	$0	$0	$20,100	$0	$0	$0
Present worth	$0	$0	$20,100	$0	$0	$0
Cumulative	$0	$0	$20,100	$20,100	$20,100	$20,100
Surplus capacity, MW	0.5	0.2	61.2	59.2	40.8	37.6
Utility demand, MW	0.0	0.0	14.9	16.9	33.9	52.6
Energy generated, MWh/yr						
On digester gas						
on-peak	0	0	0	0	0	0
off-peak	0	0	0	0	0	0
On purchased fuel						
On-peak						
C.C.	0	0	0	0	0	0
Diesel	27431	29758	60340	61152	34821	34821
Off-peak						
C.C.	0	0	0	0	0	0
Diesel	43468	47155	0	0	0	0
Total	70900	76913	60340	61152	34821	34821

TABLE A-2
ALTERNATIVE 1 - NO NEW GENERATION, DUAL UTILITY FEEDER, NO DIGESTERS
(Continued)

Energy purchased, MWh/yr						
On-peak	-0	0	4313	7378	50866	87021
Off-peak	-0	0	102450	108594	135781	193074
Total	-0	0	106764	115972	186647	280095
Grand total	70900	76913	167104	177125	221469	314916
Error	-0	0	-0	-0	0	0
Heating requirements, MBtu/yr						
Total heating	33215	33215	33215	33215	33215	33215
on/off pk	52633	52633	52633	52633	52633	52633
Diesel heat	0	0	0	0	0	0
on/off pk	0	0	0	0	0	0
CC extraction	0	0	0	0	0	0
on/off pk	0	0	0	0	0	0
From boilers	85848	85848	85848	85848	85848	85848
Equivalent fuel	100998	100998	100998	100998	100998	100998
Annual costs, $1000/yr						
Electric utility						
Facilities	$0	$0	$0	$0	$0	$0
Demand	$0	$0	$1,748	$1,982	$3,969	$6,151
On-peak energy	($0)	$0	$128	$218	$1,504	$2,573
Off-peak energy	($0)	$0	$641	$680	$850	$1,209
Fuel adjustment	($0)	$0	$2,185	$2,374	$3,821	$5,734
Total electric	($0)	$0	$4,703	$5,254	$10,144	$15,667
Heating fuel	$379	$379	$379	$379	$379	$379
Engine fuel	$2,446	$2,654	$2,082	$2,110	$1,202	$1,202
Comb cycle fuel	$0	$0	$0	$0	$0	$0
Total fuel	$2,825	$3,033	$2,461	$2,489	$1,580	$1,580
O&M cost	$322	$430	$430	$430	$240	$240
Total cost	$3,147	$3,463	$7,593	$8,173	$11,964	$17,487
Present worth	$0	$0	$13,426	$12,247	$28,071	$87,652
Cumulative	$0	$0	$13,426	$25,673	$53,745	$141,396
TOTAL PRES. WORTH	$0	$0	$33,526	$45,773	$73,845	$161,496

SUMMARY PRESENT WORTH COST:
$1,000

Capital:	$20,100
Operating:	$141,396
Total:	$161,496

TABLE A-3

ALTERNATIVE 3A - 58MW CC, SINGLE UTILITY FEEDER, NO DIGESTERS

First year	1986	1988	1991	1993	1995	1999
Last year	1987	1990	1992	1994	1998	2020
New capacity, units						
70 MW feeder	0	0	0	0	1	1
58.0 MW C.C.	0	0	1	1	1	1
Cumulative MW						
Committed	16.1	21.5	21.5	21.5	12.0	12.0
Feeder	0.0	0.0	0.0	0.0	70.0	70.0
C.C.	0.0	0.0	57.7	57.7	57.7	57.7
Total	16.1	21.5	79.2	79.2	139.7	139.7
Largest unit	1.5	6.0	58.0	58.0	70.0	70.0
Secure MW	14.6	15.5	21.2	21.2	69.7	69.7
Capital costs, 1000$						
Feeder	$0	$0	$0	$0	$9,500	$0
C.C.	$0	$0	$54,000	$0	$0	$0
Total	$0	$0	$54,000	$0	$9,500	$0
Present worth	$0	$0	$54,000	$0	$6,823	$0
Cumulative	$0	$0	$54,000	$54,000	$60,823	$60,823
Surplus capacity, MW	0.5	0.2	-9.2	-11.2	28.5	25.2
Utility demand, MW	0.0	0.0	0.0	0.0	0.0	3.2
Energy generated, MWh/yr						
On digester gas						
on-peak	0	0	0	0	0	0
off-peak	0	0	0	0	0	0
On purchased fuel						
On-peak						
C.C.	0	0	64653	68530	85687	121824
Diesel	27431	29758	0	0	0	17
Off-peak						
C.C.	0	0	102450	108594	0	0
Diesel	43468	47155	0	0	0	0
Total	70900	76913	167104	177125	85687	121841

TABLE A-3
ALTERNATIVE 3A - 58MW CC, SINGLE UTILITY FEEDER, NO DIGESTERS
(Continued)

Energy purchased, MWh/yr						
On-peak	-0	0	0	0	0	1
Off-peak	-0	0	0	0	135781	193074
Total	-0	0	0	0	135781	193075
Grand total	70900	76913	167104	177125	221469	314916
Error	-0	0	0	0	0	0
Heating requirements, MBtu/yr						
Total heating	33215	33215	33215	33215	33215	33215
on/off pk	52633	52633	52633	52633	52633	52633
Diesel heat	0	0	0	0	0	0
on/off pk	0	0	0	0	0	0
CC extraction	0	0	153936	163168	204017	290058
on/off pk	0	0	243929	258558	0	0
From boilers	85848	85848	0	0	52633	52633
Equivalent fuel	100998	100998	0	0	61921	61921
Annual costs, $1000/yr						
Electric utility						
Facilities	$0	$0	$0	$0	$0	$0
Demand	$0	$0	$0	$0	$0	$376
On-peak energy	($0)	$0	$0	$0	$0	$0
Off-peak energy	($0)	$0	$0	$0	$850	$1,209
Fuel adjustment	($0)	$0	$0	$0	$2,779	$3,952
Total electric	($0)	$0	$0	$0	$3,629	$5,537
Heating fuel	$379	$379	$0	$0	$232	$232
Engine fuel	$2,446	$2,654	$0	$0	$0	$1
Comb cycle fuel	$0	$0	$5,573	$5,907	$2,858	$4,063
Total fuel	$2,825	$3,033	$5,573	$5,907	$3,090	$4,296
O&M cost	$322	$430	$2,736	$2,736	$2,546	$2,546
Total cost	$3,147	$3,463	$8,309	$8,643	$9,266	$12,379
Present worth	$0	$0	$14,691	$12,952	$21,739	$62,048
Cumulative	$0	$0	$14,691	$27,643	$49,383	$111,430
TOTAL PRES. WORTH	$0	$0	$68,691	$81,643	$110,206	$172,254

SUMMARY PRESENT WORTH COST:
$1,000

Capital:	$60,823
Operating:	$111,430
Total:	$172,254

TABLE A-4

ALTERNATIVE 3B - 25.7 MW CC, DUAL UTILITY FEEDERS, NO DIGESTERS

First year	1986	1988	1991	1993	1995	1999
Last year	1987	1990	1992	1994	1998	2020
New capacity, units						
70 MW feeder	0	0	2	2	2	2
25.7 MW C.C.	0	0	0	0	1	1
Cumulative MW						
Committed	16.1	21.5	21.5	21.5	12.0	12.0
Feeder	0.0	0.0	140.0	140.0	140.0	140.0
C.C.	0.0	0.0	0.0	0.0	25.4	25.4
Total	16.1	21.5	161.5	161.5	177.4	177.4
Largest unit	1.5	6.0	70.0	70.0	70.0	70.0
Secure MW	14.6	15.5	91.5	91.5	107.4	107.4
Capital costs, 1000$						
Feeder	$0	$0	$20,100	$0	$0	$0
C.C.	$0	$0	$0	$0	$23,310	$0
Total	$0	$0	$20,100	$0	$23,310	$0
Present worth	$0	$0	$20,100	$0	$16,743	$0
Cumulative	$0	$0	$20,100	$20,100	$36,843	$36,843
Surplus capacity, MW	0.5	0.2	61.2	59.2	66.2	62.9
Utility demand, MW	0.0	0.0	14.9	16.9	12.2	30.9
Energy generated, MWh/yr						
On digester gas						
on-peak	0	0	0	0	0	0
off-peak	0	0	0	0	0	0
On purchased fuel						
On-peak						
C.C.	0	0	0	0	72870	73561
Diesel	27431	29758	60340	61152	12794	33267
Off-peak						
C.C.	0	0	0	0	0	0
Diesel	43468	47155	0	0	0	0
Total	70900	76913	60340	61152	85664	106828

TABLE A-4

ALTERNATIVE 3B - 25.7 MW CC, DUAL UTILITY FEEDERS, NO DIGESTERS

(Continued)

Energy purchased, MWh/yr						
On-peak	-0	0	4313	7378	23	15015
Off-peak	-0	0	102450	108594	135781	193074
Total	-0	0	106764	115972	135805	208088
Grand total	70900	76913	167104	177125	221469	314916
Error	-0	0	-0	-0	0	0
Heating requirements, MBtu/yr						
Total heating	33215	33215	33215	33215	33215	33215
on/off pk	52633	52633	52633	52633	52633	52633
Diesel heat	0	0	0	0	0	0
on/off pk	0	0	0	0	0	0
CC extraction	0	0	0	0	173499	175146
on/off pk	0	0	0	0	0	0
From boilers	85848	85848	85848	85848	52633	52633
Equivalent fuel	100998	100998	100998	100998	61921	61921
Annual costs, $1000/yr						
Electric utility						
Facilities	$0	$0	$0	$0	$0	$0
Demand	$0	$0	$1,748	$1,982	$1,430	$3,612
On-peak energy	($0)	$0	$128	$218	$1	$444
Off-peak energy	($0)	$0	$641	$680	$850	$1,209
Fuel adjustment	($0)	$0	$2,185	$2,374	$2,780	$4,260
Total electric	($0)	$0	$4,703	$5,254	$5,060	$9,524
Heating fuel	$379	$379	$379	$379	$232	$232
Engine fuel	$2,446	$2,654	$2,082	$2,110	$441	$1,148
Comb cycle fuel	$0	$0	$0	$0	$2,496	$2,520
Total fuel	$2,825	$3,033	$2,461	$2,489	$3,170	$3,900
O&M cost	$322	$430	$430	$430	$1,254	$1,254
Total cost	$3,147	$3,463	$7,593	$8,173	$9,484	$14,678
Present worth	$0	$0	$13,426	$12,247	$22,252	$73,570
Cumulative	$0	$0	$13,426	$25,673	$47,925	$121,494
TOTAL PRES. WORTH	$0	$0	$33,526	$45,773	$84,767	$158,337

SUMMARY PRESENT WORTH COST:

$1,000

Capital:	$36,843
Operating:	$121,494
Total:	$158,337

TABLE A-5

ALTERNATIVE 3B - 15 MW CC, DUAL UTILITY FEEDERS, NO DIGESTERS

First year	1986	1988	1991	1993	1995	1999
Last year	1987	1990	1992	1994	1998	2020
New capacity, units						
70 MW feeder	0	0	1	1	2	2
15.0 MW C.C.	0	0	1	1	1	1
Cumulative MW						
Committed	16.1	21.5	21.5	21.5	12.0	12.0
Feeder	0.0	0.0	70.0	70.0	140.0	140.0
C.C.	0.0	0.0	14.7	14.7	14.7	14.7
Total	16.1	21.5	106.2	106.2	166.7	166.7
Largest unit	1.5	6.0	70.0	70.0	70.0	70.0
Secure MW	14.6	15.5	36.2	36.2	96.7	96.7
Capital costs, 1000$						
Feeder	$0	$0	$9,500	$0	$10,600	$0
C.C.	$0	$0	$13,854	$0	$0	$0
Total	$0	$0	$23,354	$0	$10,600	$0
Present worth	$0	$0	$23,354	$0	$7,614	$0
Cumulative	$0	$0	$23,354	$23,354	$30,968	$30,968
Surplus capacity, MW	0.5	0.2	5.8	3.8	55.5	52.2
Utility demand, MW	0.0	0.0	2.4	4.4	21.4	40.0
Energy generated, MWh/yr						
On digester gas						
on-peak	0	0	0	0	0	0
off-peak	0	0	0	0	0	0
On purchased fuel						
On-peak						
C.C.	0	0	42513	42516	42523	42523
Diesel	27431	29758	22139	26012	33442	34806
Off-peak						
C.C.	0	0	0	0	0	0
Diesel	43468	47155	0	0	0	0
Total	70900	76913	64652	68527	75965	77329

TABLE A-5
ALTERNATIVE 3B - 15 MW CC, DUAL UTILITY FEEDERS, NO DIGESTERS
(Continued)

Energy purchased, MWh/yr						
On-peak	-0	0	1	3	9723	44513
Off-peak	-0	0	102450	108594	135781	193074
Total	-0	0	102451	108597	145504	237587
Grand total	70900	76913	167104	177125	221469	314916
Error	-0	0	-0	0	0	0
Heating requirements, MBtu/yr						
Total heating	33215	33215	33215	33215	33215	33215
on/off pk	52633	52633	52633	52633	52633	52633
Diesel heat	0	0	0	0	0	0
on/off pk	0	0	0	0	0	0
CC extraction	0	0	101222	101228	101246	101246
on/off pk	0	0	0	0	0	0
From boilers	85848	85848	52633	52633	52633	52633
Equivalent fuel	100998	100998	61921	61921	61921	61921
Annual costs, $1000/yr						
Electric utility						
Facilities	$0	$0	$0	$0	$0	$0
Demand	$0	$0	$280	$514	$2,501	$4,683
On-peak energy	($0)	$0	$0	$0	$287	$1,316
Off-peak energy	($0)	$0	$641	$680	$850	$1,209
Fuel adjustment	($0)	$0	$2,097	$2,223	$2,978	$4,863
Total electric	($0)	$0	$3,019	$3,417	$6,617	$12,072
Heating fuel	$379	$379	$232	$232	$232	$232
Engine fuel	$2,446	$2,654	$764	$898	$1,154	$1,201
Comb cycle fuel	$0	$0	$1,546	$1,546	$1,546	$1,546
Total fuel	$2,825	$3,033	$2,542	$2,676	$2,932	$2,979
O&M cost	$322	$430	$1,016	$1,016	$826	$826
Total cost	$3,147	$3,463	$6,577	$7,109	$10,376	$15,877
Present worth	$0	$0	$11,629	$10,653	$24,344	$79,582
Cumulative	$0	$0	$11,629	$22,281	$46,625	$126,208
TOTAL PRES. WORTH	$0	$0	$34,983	$45,635	$77,593	$157,175

SUMMARY PRESENT WORTH COST:
$1,000

Capital:	$30,968
Operating:	$126,208
Total:	$157,175

TABLE A-5

ALTERNATIVE 3B - 15 MW CC, DUAL UTILITY FEEDERS, NO DIGESTERS

First year	1986	1988	1991	1993	1995	1999
Last year	1987	1990	1992	1994	1998	2020
New capacity, units						
70 MW feeder	0	0	2	2	2	2
15.0 MW C.C.	0	0	0	0	1	1
Cumulative MW						
Committed	16.1	21.5	21.5	21.5	12.0	12.0
Feeder	0.0	0.0	140.0	140.0	140.0	140.0
C.C.	0.0	0.0	0.0	0.0	14.7	14.7
Total	16.1	21.5	161.5	161.5	166.7	166.7
Largest unit	1.5	6.0	70.0	70.0	70.0	70.0
Secure MW	14.6	15.5	91.5	91.5	96.7	96.7
Capital costs, 1000$						
Feeder	$0	$0	$20,100	$0	$0	$0
C.C.	$0	$0	$0	$0	$13,854	$0
Total	$0	$0	$20,100	$0	$13,854	$0
Present worth	$0	$0	$20,100	$0	$9,951	$0
Cumulative	$0	$0	$20,100	$20,100	$30,051	$30,051
Surplus capacity, MW	0.5	0.2	61.2	59.2	55.5	52.2
Utility demand, MW	0.0	0.0	14.9	16.9	21.4	40.0
Energy generated, MWh/yr						
On digester gas						
on-peak	0	0	0	0	0	0
off-peak	0	0	0	0	0	0
On purchased fuel						
On-peak						
C.C.	0	0	0	0	42523	42523
Diesel	27431	29758	60340	61152	33442	34806
Off-peak						
C.C.	0	0	0	0	0	0
Diesel	43468	47155	0	0	0	0
Total	70900	76913	60340	61152	75965	77329

TABLE A-5
ALTERNATIVE 3B - 15 MW CC, DUAL UTILITY FEEDERS, NO DIGESTERS
(Continued)

Energy purchased, MWh/yr						
On-peak	-0	0	4313	7378	9723	44513
Off-peak	-0	0	102450	108594	135781	193074
Total	-0	0	106764	115972	145504	237587
Grand total	70900	76913	167104	177125	221469	314916
Error	-0	0	-0	-0	0	0
Heating requirements, MBtu/yr						
Total heating	33215	33215	33215	33215	33215	33215
on/off pk	52633	52633	52633	52633	52633	52633
Diesel heat	0	0	0	0	0	0
on/off pk	0	0	0	0	0	0
CC extraction	0	0	0	0	101246	101246
on/off pk	0	0	0	0	0	0
From boilers	85848	85848	85848	85848	52633	52633
Equivalent fuel	100998	100998	100998	100998	61921	61921
Annual costs, $1000/yr						
Electric utility						
Facilities	$0	$0	$0	$0	$0	$0
Demand	$0	$0	$1,748	$1,982	$2,501	$4,683
On-peak energy	($0)	$0	$128	$218	$287	$1,316
Off-peak energy	($0)	$0	$641	$680	$850	$1,209
Fuel adjustment	($0)	$0	$2,185	$2,374	$2,978	$4,863
Total electric	($0)	$0	$4,703	$5,254	$6,617	$12,072
Heating fuel	$379	$379	$379	$379	$232	$232
Engine fuel	$2,446	$2,654	$2,082	$2,110	$1,154	$1,201
Comb cycle fuel	$0	$0	$0	$0	$1,546	$1,546
Total fuel	$2,825	$3,033	$2,461	$2,489	$2,932	$2,979
O&M cost	$322	$430	$430	$430	$826	$826
Total cost	$3,147	$3,463	$7,593	$8,173	$10,376	$15,877
Present worth	$0	$0	$13,426	$12,247	$24,344	$79,582
Cumulative	$0	$0	$13,426	$25,673	$50,017	$129,600
TOTAL PRES. WORTH	$0	$0	$33,526	$45,773	$80,068	$159,651

SUMMARY PRESENT WORTH COST:
$1,000

Capital:	$30,051
Operating:	$129,600
Total:	$159,651

Secondary Treatment Facilities Plan

Volume III

Appendix I
Water Supply

APPENDIX I

WATER SUPPLY

1.0 INTRODUCTION

The Deer Island Secondary Treatment facilities will require a sufficient supply of potable water for the sanitary needs of the workers and for laboratory needs. In addition, potable water will be used for critical mechanical needs and for critical chemical mixing.

The purpose of this report is to discuss the plant's water requirements and the alternatives available to provide the required water.

The contents of Appendix I were compiled in January of 1987 and the analysis were conducted based upon the water systems that existed at that time. In the year since then the MWRA has proceeded with the design of system improvements for the Northern High Distribution System, the replacement of the meter and pressure reducing valve at the Winthrop/Revere Line (referred to in the report as Meter 41), the meter to Deer Island, and the Town of Winthrop's standpipe inlet. These improvements are expected to have a beneficial effect on the available H.G.L. The reader is advised that the existing HGL at shaft 9A which feeds the NHDS is between 245-255 BCBD during average and peak demands. Proposed improvements to the aqueduct/tunnel system which are in the MWRA Capital Improvement Program will increase the gradient at Shaft 9A.

A 1974 report prepared by Whitman & Howard recommended a minimum HGL of 228 ft BCBD for Winthrop. This minimum HGL was for the low side of the PRV at Meter 41. Improvements presently under design by the MWRA include a transmission main from the vicinity of shaft 94 to meter 41 which is being designed to keep the minimum HGL above 230.

In Section 6.2 the Analysis of Alternatives, it was assumed that the worst case scenario on the upstream side of Meter 41 was associated with maximum day demands. The assumptions were for HGL at the Winthrop/Revere line of 195.75 BCBD. This was for existing conditions in NHDS. This is lower than the recommended W&H value of 228. It is assumed that this condition is not typical over a diurnal period, but is the worst case under existing conditions and would be short-termed (approx 3 to 6 hr.). With the appropriate storage, this situation can be overcome. Since storage and system improvements are problems that are to be solved during the design of facilities, the scenario analyzed during Facility planning was a stressed condition. This condition will not exist once the currently proposed improvements of meter 41, both upstream and downstream, are completed.

2.0 WATER REQUIREMENTS

Potable water is presently used at the treatment plant for toilets, sinks, drinking fountains, sludge heaters, engine cooling, equipment flushing and washdown, and seal water. Average and maximum present consumptions are 0.1 million gallons per day (mgd) and 0.2 mgd, respectively.

The potable water demands were established by tabulating identifiable water needs and comparing that tabulation to the potable water consumption at similar sized plants. Tabulated potable water chemicals include:

Concrete Batch Plant	50,000 gpd
Construction Workshop (peak)	37,000 gpd
Prison (measured)	228,000 gpd
Existing Plant (measured)	112,000 gpd
Fast Track Power Cooling (est)	80,000
Cryogenic Facility (est)	200,000
Plant Employees (peak)	11,000
Pump seals (est)	150,000 gpd
Laboratory	10,000 gpd
Residuals	unknown
Sub Total	878,000 gpd

This tabulated demand was then compared to actual demands at other similar facilities.

The amount of potable water utilized at other large treatment facilities is comparable. The usage at other treatment facilities is influenced by the availability of potable water and the quality of plant effluent. Five similar facilities, their design size, and potable water usage are shown in Table I-1:

TABLE I-1

TREATMENT PLANT WATER USE

Plant	Treatment Capacity	Potable Water
Chicago Calumet Plant	220 mgd	2.4 mgd
Chicago West South West	1200 mgd	0.7 mgd
District of Columbia WPCP Blue Plains	370 mgd	1.0 mgd
County Sanitation District of Los Angeles	350 mgd	1.2 mgd
Detroit, Michigan	840 mgd	6.0 mgd

For the new treatment facility, it is estimated that water use will increase to an average consumption of 1.0 mgd and a maximum consumption of 2.0 mgd. In order to limit the consumption of potable water to a maximum of 2.0 mgd, the Deer Island facility will be designed to reuse treated secondary effluent for those purposes which do not require potable water. Nonpotable water is designated "plant water" and will be used for pass-through engine cooling, process equipment flushing, and equipment washdown. Plant water will be provided by a 45 mgd (31,250 gallons per minute) plant water pump station discharging directly to the plant water distribution system. The plant water pump station will consist of five pumps in parallel, and normally will operate with three or fewer pumps on-line, one pump on standby, and one pump available for maintenance. Information with respect to plant water can be found in Volume III, Section 11.2 "Maintenance of Plant Operations".

The uses for plant water will change as the plant progresses through the phases of construction, primary plant operation, and ultimately, secondary plant operation. During construction of the primary facilities, secondary effluent will not be available to supply the noncritical primary plant processes and potable water will be used. The largest identified water use is for pass-through engine cooling water used for the recommended power facilities. These are configured to utilize primary effluent. Upon completion of secondary facilities, these noncritical primary plant process water requirements can be transferred to the process water system.

It is recommended that, in addition to potable water for daily needs, a supply of potable water should also be available for firefighting purposes. It is unlikely that a municipal fire department, either Boston's or Winthrop's, would connect its fire hoses to anything but a potable water supply. The required volume of water for firefighting purposes is determined by the size and height of a structure, the flammability of the structure and its contents, and the presence or absence of a sprinkler system. In order to reduce the amount of water necessary for firefighting, it was assumed that all critical structures and gallery areas will be protected by sprinkler systems. It was also assumed that the maximum required fire flow is 3,000 gpm (4.32 mgd). This is adequate for a two-storey building constructed of noncombustible materials, with exterior dimensions of 150 ft by 150 ft. The fire flow must be available for a three-hour duration and must be available either from the water main supplying the site or from nearby storage. Three thousand gallons per minute for three hours equals 540,000 gallons.

3.0 DATUM PLANES

All elevations in this memorandum are shown in Boston City Base Datum (BCBD) which is the datum used by the Massachusetts Water Resources Authority's Water Division. The relationship to other datums are as follows:

To Convert From	To		
Boston City Base (BCBD)	MDC Sewer Datum (MDCSD)	Add 99.97 ft	

To Convert From	To		
BCBD	U.S. Geological Survey (USGS)	Subtract 5.65 ft	

To Convert From	To		
USGS	MDCSD	Add 105.12 ft	

To Convert From	To		
BCBD	Pounds per square inch	BCBD in feet = where h =	2.289 h+31.33 psi head in psi

4.0 EXISTING WATER SUPPLY

Potable water is currently supplied to Deer Island from the Town of Winthrop's water system. The Town's system is supplied by the MWRA's Northern High Distribution System (NHDS). Water is delivered to this system from shafts 9, 9A, and the Spot Pond pumping station.

The Winthrop connection to the NHDS, located at the Revere line, is known as MWRA Meter 41. This consists of a 20-inch main, a 16-inch main, pressure reducing valves (PRV), and a meter. At present only one of the lines, typically the 16-inch line, is open. Currently, the hydraulic grade line upstream of the PRV valve is approximately elevation 240 Boston City Base Datum (BCBD) under average-day demands and drops to approximately elevation 200 BCBD under peak flows. This section of the Northern High System was analyzed by the MDC in 1981 for the probable worst case condition of a maximum day demand upon the system in addition to a dual fire flow requirement of 4,000 gpm in East Boston and a fire flow requirement of 3,500 gpm in Winthrop. For this worst case condition, the Hydraulic Grade Line at Meter 41 dropped to 158 BCBD. (It should be noted that this HGL is based upon assumed friction factors for the NHDS system and proposed upstream, shafts 9 and 9A, improvements.)

The Town of Winthrop's distribution system is a single zone pressure system that is operated at a pressure lower than the MWRA's northern high system. Pressures are controlled by regulators on the MWRA-Winthrop connection. The Winthrop System was originally designed to operate with the MWRA regulators set so that the maximum pressure within Winthrop did not exceed 75 psi (el. 203 BCBD). The Town has varied the pressure at times in order to meet the needs of its system.

At present, the Town's average-day demand is approximately 2 mgd. The Town is nearly 100 percent developed, and the Town's future water needs are expected to increase slowly, by no more than 10 percent. The ratio of average-day demand to maximum day demands of 1.75, which is typical for communities similar to Winthrop, was used for this evaluation. The fire flow required for Winthrop has been estimated as 3,500 gpm as given in the earlier MDC reports, and was used for this evaluation.

The administration of the existing water supply facilities on Deer Island involve the Boston Public Facilities Department, the Winthrop Water Commissioners, the Winthrop Selectmen's office, and the MWRA. Deer Island's water is provided by a connection from the Winthrop distribution system. The MWRA's treatment plant and the Suffolk County House of Correction are customers of the Winthrop Water Department.

Several water mains have been extended from Winthrop to Deer Island over the years. Both a 6-inch and a 12-inch City of Boston water main were installed in the 1800s across Shirley Gut before the gut was filled. The status of the 6-inch line is unknown. There are also two 8-inch mains to the island. One provides potable water to the Deer Island House of Correction, and one provides potable water to the existing treatment plant. All of these various lines are interconnected.

Fire flow tests performed in late November of 1986 by the Boston Water and Sewer Commission showed the following results:

a.	8-inch main at piggery	450 gpm at 20 psi
b.	Unknown size main at gate east of guard booth	750 gpm at 20 psi

Universal Engineering has conducted an examination of the water system on Deer Island on behalf of the City of Boston to assess its capacity as part of safety improvements for the House of Correction.

5.0 AVAILABLE STORAGE

There is no potable water storage at present on Deer Island. In Winthrop, storage is provided by an uncovered standpipe located on top of Cottage Hill, near Point Shirley. The standpipe is 100 ft high and 40 ft in diameter and has a theoretical capacity of 0.94 million gallons. The tank's overflow elevation is 201.59 BCBD, but because of the pressure reduction at Meter 41, the Town can not fully utilize the tank, and the usable storage is inadequate to meet the peak hourly fluctuations during times of maximum daily demands. The available storage in the Winthrop system is inadequate for the Town's needs and, as such, offers no reserve capacity to the plant site.

The existing and future conditions with regard to water needs in Winthrop and Deer Island are summarized below:

Present and Projected Water Consumption in mgd

	1987	2000
Average Daily Consumption		
Winthrop	2.0	2.2
Deer Island	0.1	1.0
Total	2.1	3.2
Maximum Daily Consumption		
Winthrop	3.5	3.9
Deer Island	.2	2.0
Total	3.7	5.9
Required Fire Flow		
Winthrop	5.04 (3,500 gpm)	5.04 (3,500 gpm)
Deer Island	N/A	4.32 (3,000 gpm)

6.0 SUPPLY ALTERNATIVES

6.1 ALTERNATIVES ASSOCIATED WITH REVERE/WINTHROP METER 41

The new plant's maximum daily potable water needs of 2.0 mgd cannot be supplied through Winthrop's system and/or through the present connections. There is an adequate supply of water available upstream of Meter 41 and alternatives for transmitting the required water from Meter 41 to the plant site have been investigated. In developing and analyzing alternatives, primary consideration was given to ensuring that the plant's supply be reliable and that it not negatively impact the Town's pressure and/or supply. Each alternative's benefits to Winthrop have also been considered.

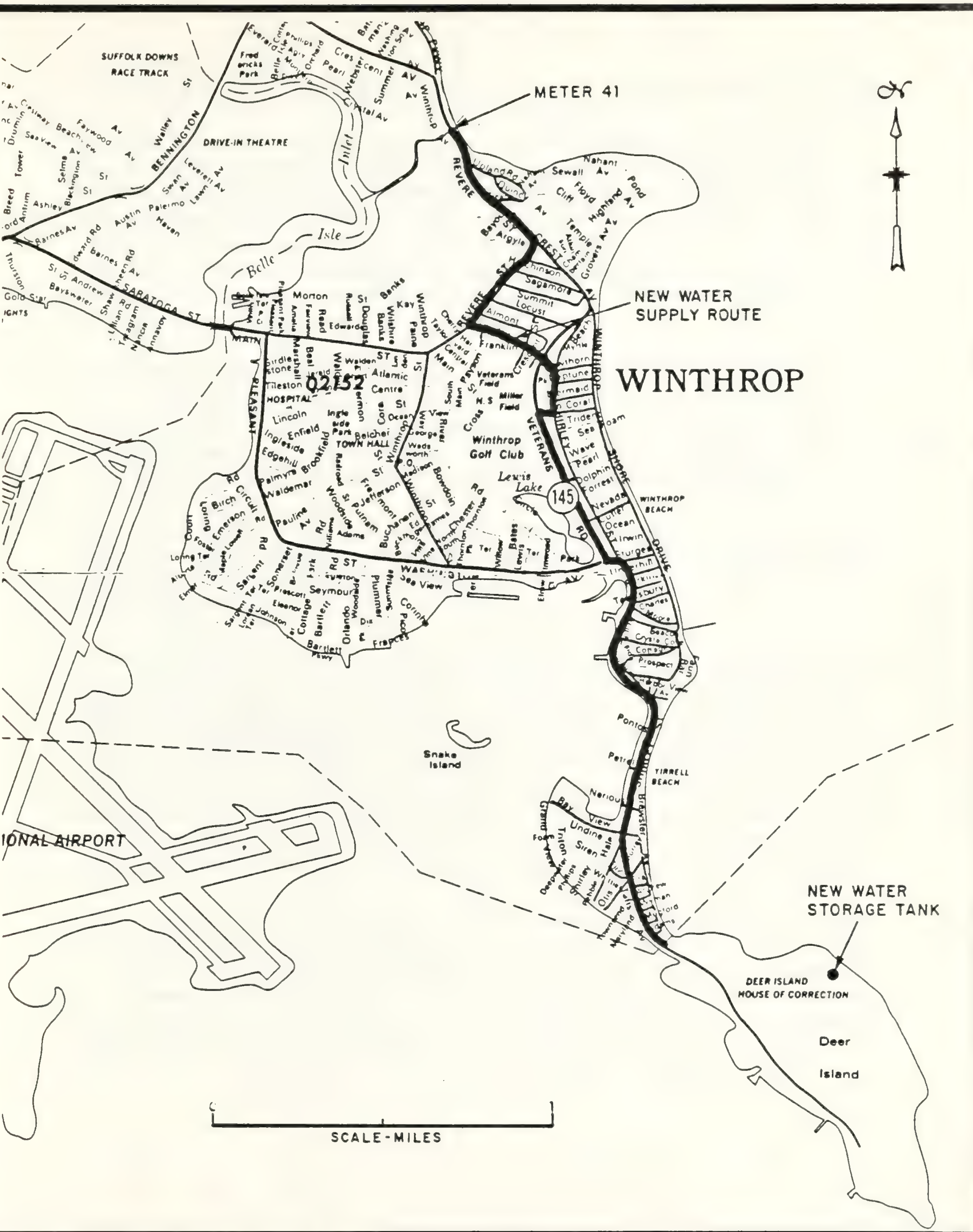
There are three alternatives to supply water to the secondary treatment facility from the vicinity of Meter 41.

The first alternative is to construct a water main dedicated to the plant's needs from upstream of the MWRA Meter 41 through Winthrop to the plant site. This water main would be sized to provide a reliable supply to the secondary treatment facility. A dedicated main would utilize the HGL available upstream of Meter 41. This water main would be controlled by MWRA, and the maintenance of the main would be MWRA's responsibility. A dedicated main would remove the present demands of the island from the Town system. With a single pipeline, however, a break anywhere along the main would cause a disruption of supply to the treatment facility.

The second option is to improve sections of the Town of Winthrop's water system and pass water from Meter 41 through Winthrop's system to the plant site. Under this option, the plant's water supply would be dependent on the condition of Winthrop's system and upon pressures available in the Winthrop system, instead of pressures upstream of Meter 41. In the event of a high water demand at the plant, lower pressures in Winthrop's water system could be experienced. The Town would have responsibility for this system's maintenance.

The third alternative is to construct a dedicated water main and to tie the dedicated main into Winthrop's water system. The advantages of this alternative are that there would be two potential sources to provide water for both the Town and the Plant. The dedicated water main would be controlled and maintained by the MWRA. Metered connections between the dedicated main and the Town could provide backup for both Town and plant emergencies and provide water to the Town during peak demand periods.

The proposed route through Winthrop for all three alternatives is shown on Figure I-1. This route was for preliminary purposes only; the actual route will be determined during the design of the facilities.



MASSACHUSETTS WATER RESOURCES AUTHORITY	FIGURE I-1 PROPOSED ROUTING OF POTABLE WATER SERVICE

6.2 ANALYSIS OF ALTERNATIVES ASSOCIATED WITH REVERE/WINTHROP METER 41

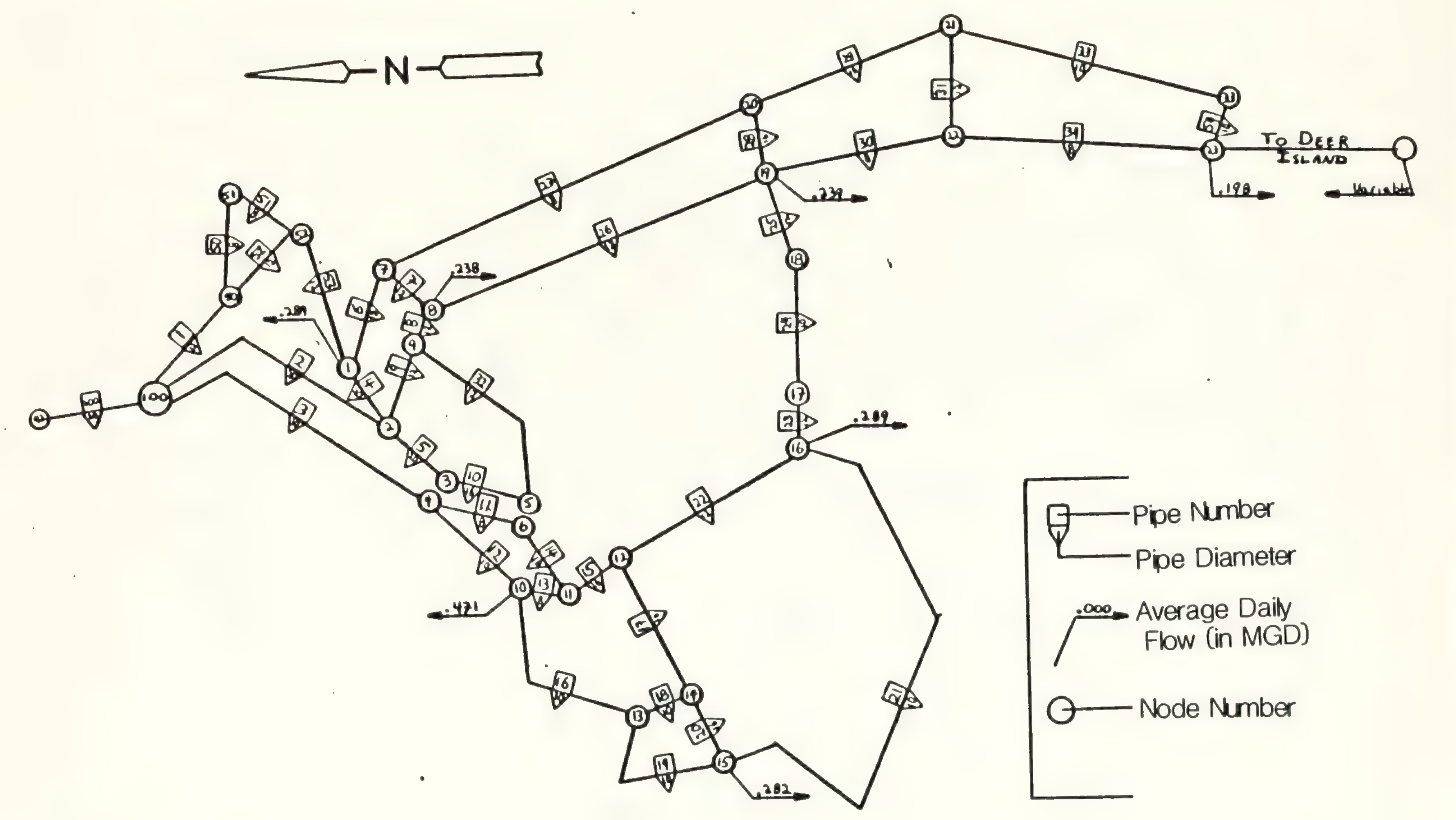
To analyze the alternatives for the supply of water to the treatment plant and their potential impacts, a preliminary hydraulic model of the Town of Winthrop's water supply system was prepared. It covered the area from MWRA Meter 41 to Point Shirley in Winthrop. While Winthrop's system consists of ductile and cast iron pipes varying in size from 6 to 20 inches in diameter, the hydraulic model included only the major pipes in the Town's system. Along the route from Meter 41 to Deer Island, the water mains consist mostly of 16-inch, 12-inch, and 10-inch diameter pipes. For continuity, a few 8-inch pipes were included in the model. The schematic of the hydraulic model is shown in Figure I-2.

The model was examined under various simulated flow conditions. Within the model, conservative friction factors and ground elevations were selected, and a maximum available hydraulic grade line (HGL) elevation of 195.75 BCBD was assumed at a point upstream of MWRA Meter 41. This HGL is slightly less than the available HGL of 200 BCBD under peak flow conditions and is assumed to reflect the worst case conditions and the impact of the plant's demands on the NHSD.

The model was utilized to determine the required diameter of a 14,400-ft-long dedicated water main. The analysis compared 16-inch and 20-inch diameter ductile iron water mains at various flow conditions. The results are depicted graphically in Figures I-3 and I-4, and are tabulated in Table I-2.

In assessing the results, a minimum pressure at all buildings of 30 psi under maximum day demands has been established as a criterion at the plant site. The equivalent HGL for the highest building would be 120 ft. Either a 16-inch or a 20-inch main can supply water to the site under maximum day demands at an HGL above 120. The 16-inch main has the capacity to deliver a fire flow of up to 1,000 gpm plus maximum day demands (this is equivalent to a rate of 3.44 mgd). The 20-inch main has the capacity to convey up to 3,000 gpm plus maximum day demands (this is equivalent to a rate of 6.32 mgd). It is unknown at this time what the impact would be on pressure at Meter 41 from a fire flow of 3,000 gpm, but it is reasonable to assume that the pressure would drop below the set point of HGL 190 for Winthrop's pressure regulator.

For a dedicated main, it is recommended that on-site storage be provided to dampen the impact of diurnal demands and to provide a supply in the event of a break in the dedicated main. The on-site storage should be equal to the estimated fire flow volume of 0.54 mg plus 50 percent of the maximum day demand, or 1.0 mg, to provide for diurnal variations in demand. The volume of on-site storage should be, as a minimum, 1.5 mg, and to be usable it should all be stored above elevation 120. The tank would be on-line storage, and an altitude valve would regulate the inflow of water to the tank, and the plant would draw their water from the tank.



MASSACHUSETTS
WATER RESOURCES
AUTHORITY

FIGURE I-2
MODEL OF WINTHROP WATER SUPPLY SYSTEM SCHEMATIC

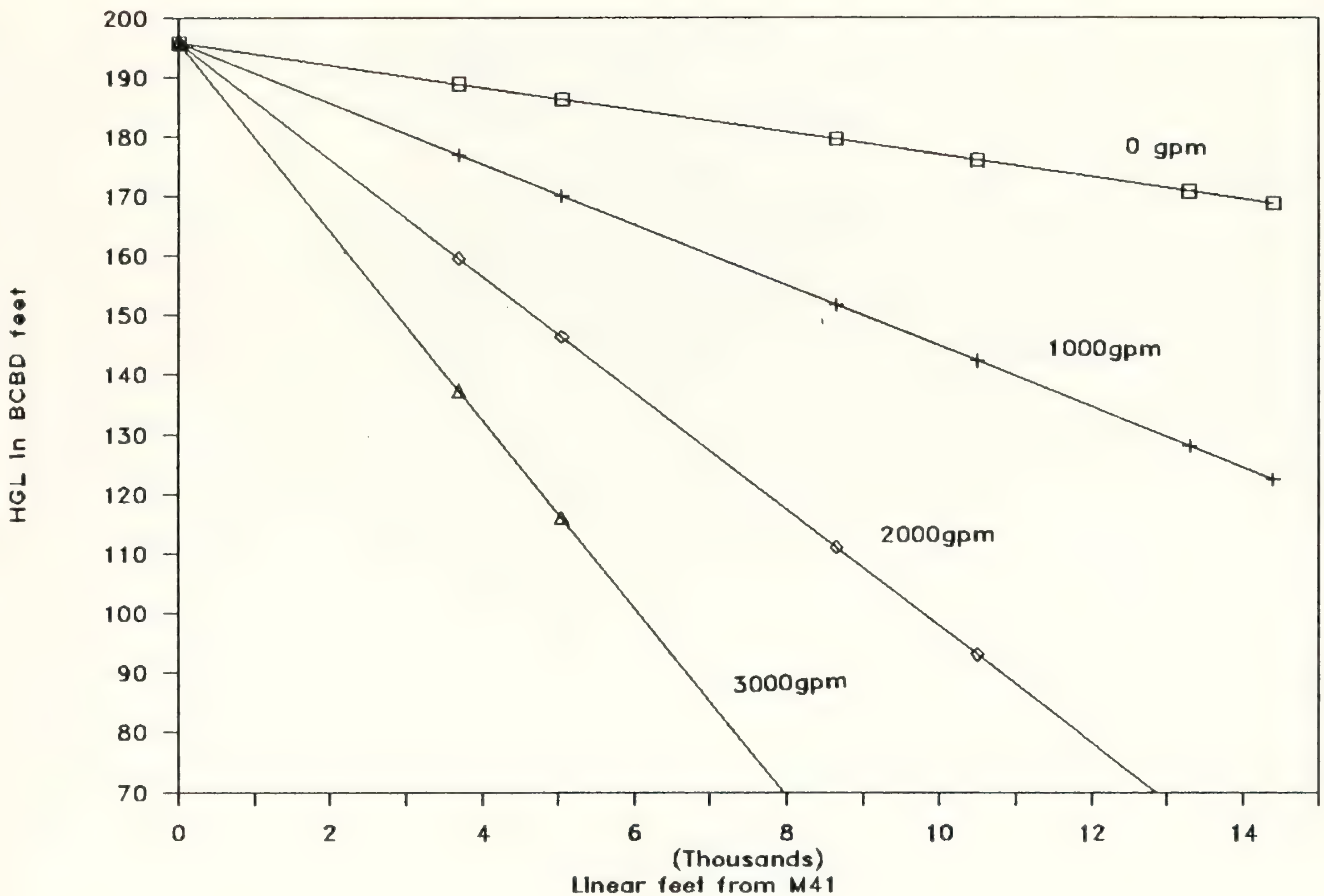


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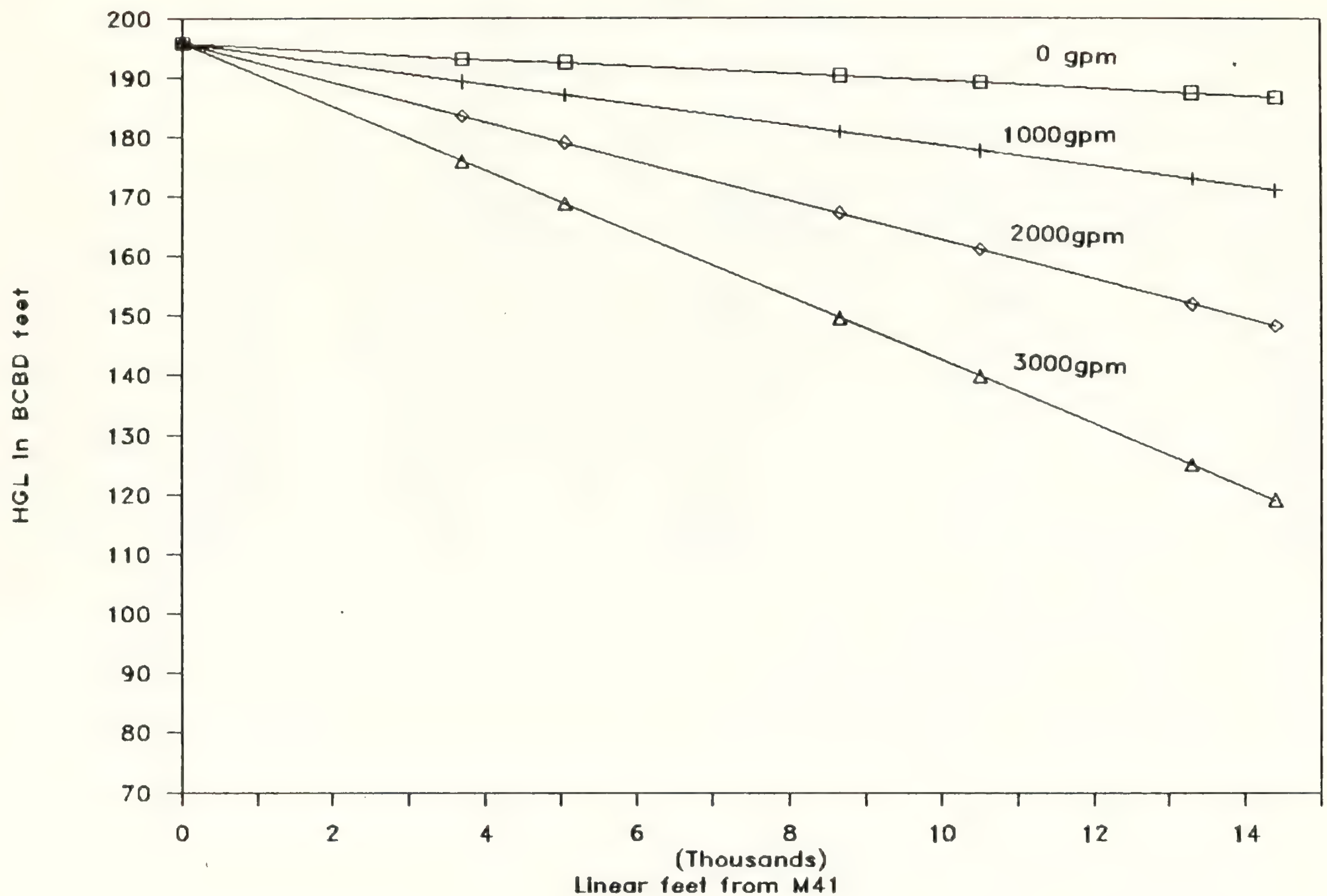
FIGURE I-3
HGL OF MWRA 16IN MAIN
(ADF OF 2.0MGD PLUS FF)



MASSACHUSETTS
WATER RESOURCES
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FIGURE I-4
HGL OF MWRA 20IN MAIN
(MAX OF 2.0MGD PLUS FF)

TABLE I-2

HGL OF DEDICATED MAINS FOR VARIOUS FLOW CONDITIONS

Dedicated 16-Inch Diameter Main

Location	Mode No.	Distance From Meter 41 in feet	HGL @41=195.75 ADF =2.OMGD FF = 0 gpm HGL	HGL @41=195.75 ADF =2.OMGD FF =1000 gpm HGL	HGL @41=195.75 ADF =2.OMGD FF = 2000 gpm HGL	HGL @41=195.75 ADF =2.OMGD FF =3000 gpm HGL
Meter 41	100	0	195.7	195.8	195.8	195.8
Bevr/Shrly	2	3700	188.8	176.9	159.5	137.3
Shrly/Beach	8	5050	186.3	170.0	146.3	116.0
Shrly/Sturgis	19	8650	179.5	151.7	111.1	59.2
Shrly/Terr/Prsp	22	10500	176.1	142.3	93.1	30.0
Taft/Adams	23	13300	170.8	128.0	65.7	-14.2
Site	230	14400	168.8	122.5	54.9	-31.6

TABLE I-2

HGL OF DEDICATED MAINS FOR VARIOUS FLOW CONDITIONS

Dedicated 20-Inch Diameter Main
(continued)

Location	Mode No.	Distance From Meter 41 in feet	HGL @41=195.75 MAX =2.OMGD FF = 0 gpm HGL	HGL @41=195.75 MAX =2.OMGD FF =1000 gpm HGL	HGL @41=195.75 MAX =2.OMGD FF = 2000 gpm HGL	HGL @41=195.75 MAX =2.OMGD FF =3000 gpm HGL
Meter 41	100	0	195.8	195.8	195.8	195.8
Bevr/Shrly	2	3700	193.0	189.4	183.5	176.0
Shrly/Beach	8	5050	192.6	187.1	179.1	168.8
Shrly/Sturgis	19	8650	190.3	180.9	167.2	149.6
Shrly/Terr/Prsp	22	10500	189.1	177.7	161.1	139.8
Taft/Adams	23	13300	187.3	172.9	151.9	124.9
Site	230	14400	186.6	171.0	148.2	119.0

For the alternative that involved the Town's system, the model was used initially to analyze the HGL for existing conditions across the Town during periods of maximum demand as well as during fire flows, but without the new plant's demands. With the Town of Winthrop's water tank on line, and using an HGL elevation of 190.00 (downstream of Meter 41), the Town's tank will stabilize at elevation 170, which is 35 feet below its overflow. For a fire flow condition of 1,000 gpm, the HGL drops rapidly and the stabilized HGL is below elevation 100. Portions of Winthrop have dwellings constructed above elevation 100 and these areas would receive inadequate pressure under these conditions. These HGLs are shown in Figure I-5 and are tabulated in Table I-3.

The Town's system was then modeled with the new plant's flows included and with the assumption that the system would be upgraded by the installation of larger pipes. The system was analyzed based on the assumption that a 20-inch pipe would be constructed from the existing 20-inch pipe at Shirley Avenue and Sturgis Street to the plant site. This improved system was analyzed assuming maximum day demand plus a 2.0 mgd flow to the plant site. It was further assumed that the existing 20-inch line was opened back to Meter 41 and that the HGL downstream of Meter 41 was 190 ft. For this condition, the HGL is approximately equivalent to the present maximum day HGL, and is depicted in Figure I-5 and tabulated in Table I-3. For this alternative, as for the dedicated main alternatives, on-site storage is provided. For this alternative, a simultaneous 3,000 gpm fire flow plus maximum day demands results in a 70 foot drop in the HGL across the Town, to HGL 120, below the elevation of several homes. The impact upon the HGL in the NHDS has not been calculated but is assumed to drop below the set point of 190 HGL at Meter 41.

For the third alternative, to construct a dedicated main and tie it into Winthrop's system to provide redundancy as well as to supplement pressures, the HGLs of the first two alternatives have been graphed together and are shown in Figure I-5 and Table I-3. Under maximum day demand, the dedicated main acts as a supplement to Winthrop's system. This is primarily true because the dedicated main utilizes the available HGL from upstream of Meter 41. The on-site storage could also be available to the Town for peak hourly needs and particularly for the fire flow needs.

The cost of the first and third alternatives discussed above have been estimated as follows:

Elevated storage reservoir	$2,336,000
Supply line through Winthrop	1,509,000
Supply lines on MWRA property	334,000
Distribution lines on MWRA property	177,000
Distribution lines in plant	388,000
Miscellaneous	135,000
	$4,879,000

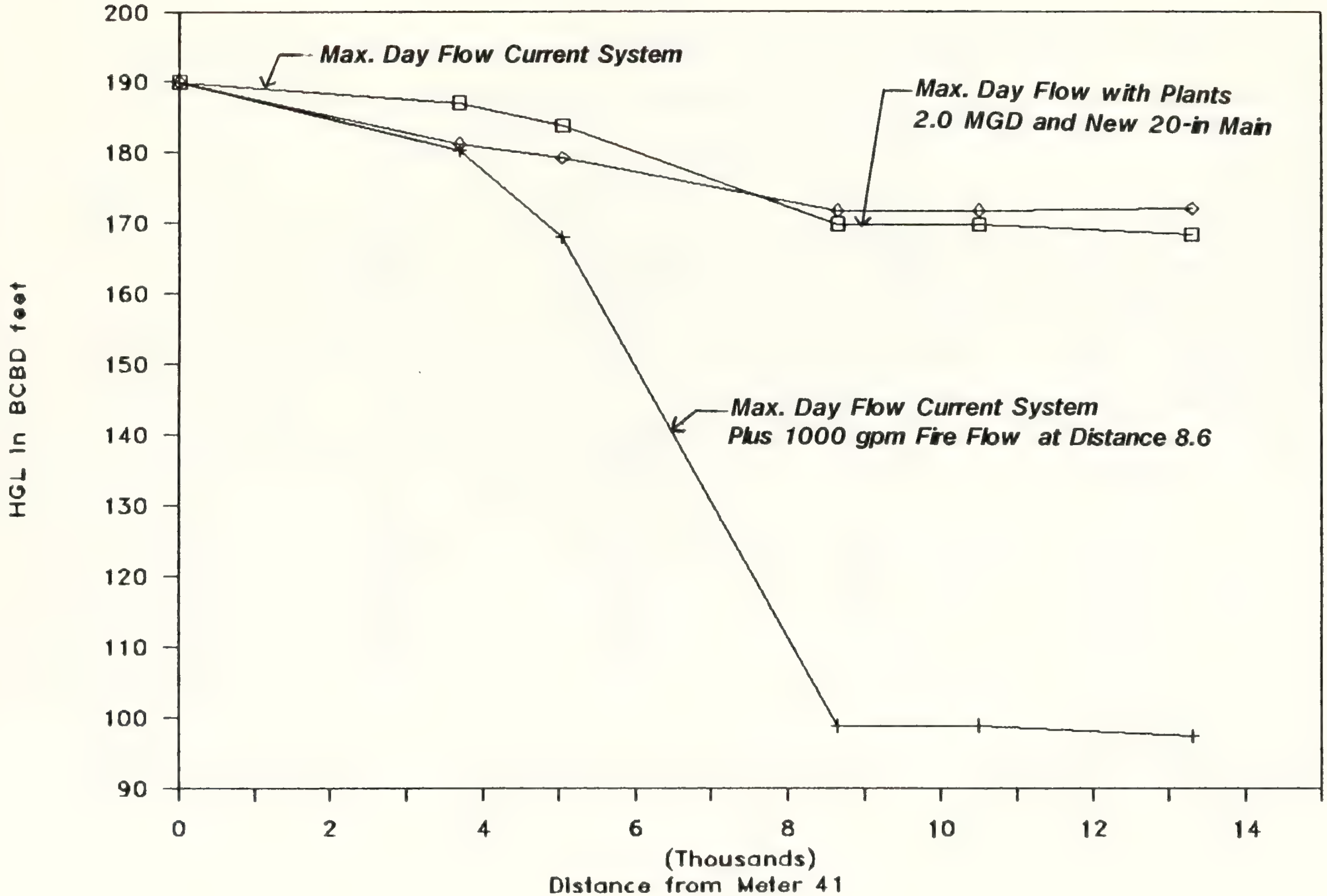

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FIGURE I-5
HGL FOR MAX DAY DEMANDS
(TOWN'S SYSTEM)

TABLE I-3

HGL OF WATER SUPPLY ALTERNATIVES

Location	No.	Distance from Mode Meter 41 in feet	Max day Present system HGL @41=19 HGL	Max Day Present system HGL @41=190 plus a FF of 1000 gpm at Mode 19 HGL	Max Day HCL @41=190 plus a 2mgd at plant via a 20 in from mode 2 to 23 HGL	Dedicated 16 in main HGL @41=195.75 ADF =2.0MGD FF = 0 gpm HGL	Dedicated 20 in main HGL @41=195.75 ADF=2.0MGD FF = 0 gpm HGL
Meter 41	100	0	190.0	190.0	190.0	195.7	195.8
Bevr/Shrly	2	3700	187.0	180.3	181.2	188.8	193.0
Shrly/Beach	8	5050	183.8	167.9	173.2	186.3	192.6
Shrly/Sturgis	19	8650	169.8	98.8	171.7	179.5	190.3
Shrly/Terr/Prsp	22	10500	169.7	98.8	171.7	176.1	189.1
Taft/Adams	23	13300	168.3	97.3	172.0	170.8	187.3
Site	230	14400				168.8	186.6

The MWRA can satisfy its needs from a 16-inch dedicated main. A 20-inch dedicated main provides a higher HGL under maximum flow conditions and would be of greater benefit to Winthrop as a means of supplementing pressure. For the MWRA's needs the overflow elevation of the on-site storage tank could be lower than the Town's present tank. At the lower elevations it would not supplement the peak hourly demand in the Town. That would be done by the dedicated main's interconnection. The on-site tank could provide additional fire protection to the Town; the extent of the fire protection would depend upon the final size and elevation of the on-site tank. The selection of the final elevation for the tank will be dependent upon an exchange of information between the MWRA and Winthrop.

6.3 ALTERNATIVES ASSOCIATED WITH CHELSEA CREEK METER 64 OR MERIDIAN STREET BRIDGE METER 3

An alternative which does not entail disruption of Winthrop's streets is to construct a 24-in. main from either the Chelsea Creek Bridge Meter 64 or the Meridian Street Bridge Meter 3, around Logan Airport using a water route through Winthrop Harbor onto Deer Island. Hydraulic analysis of this alternative indicates that the following conditions will prevail:

At Meter 3 or Meter 64:

HGL = 140 BCD at average daily flow
HGL = 115 BCD at peak hourly flow

At Deer Island:

HGL = 126.3 BCD at average daily flow
HGL = 101.3 BCD at peak hourly flow

The MWRA is currently completing cleaning and lining of one of the two 48-inch mains which supply water to the Meter 3 area. A potentially feasible water routing of this alternative is shown on Figure I-6.

The subaqueous portion of the pipeline would be constructed of 24,000 ft of 24-inch-diameter bell and spigot filament-wound vinyl ester pipe in a dredged 6-ft-deep trench backfilled with 3/4-inch crushed stone and topped with 6-inch cobble stones for protection from mechanical damage and scour. Total dredged volume would be approximately 80,000 yd^3.

The total installed cost for the subaqueous portion of the installation, based on a vendor supplied telephone estimate from Fibercast Company of Sand Springs, Oklahoma, is as follows:

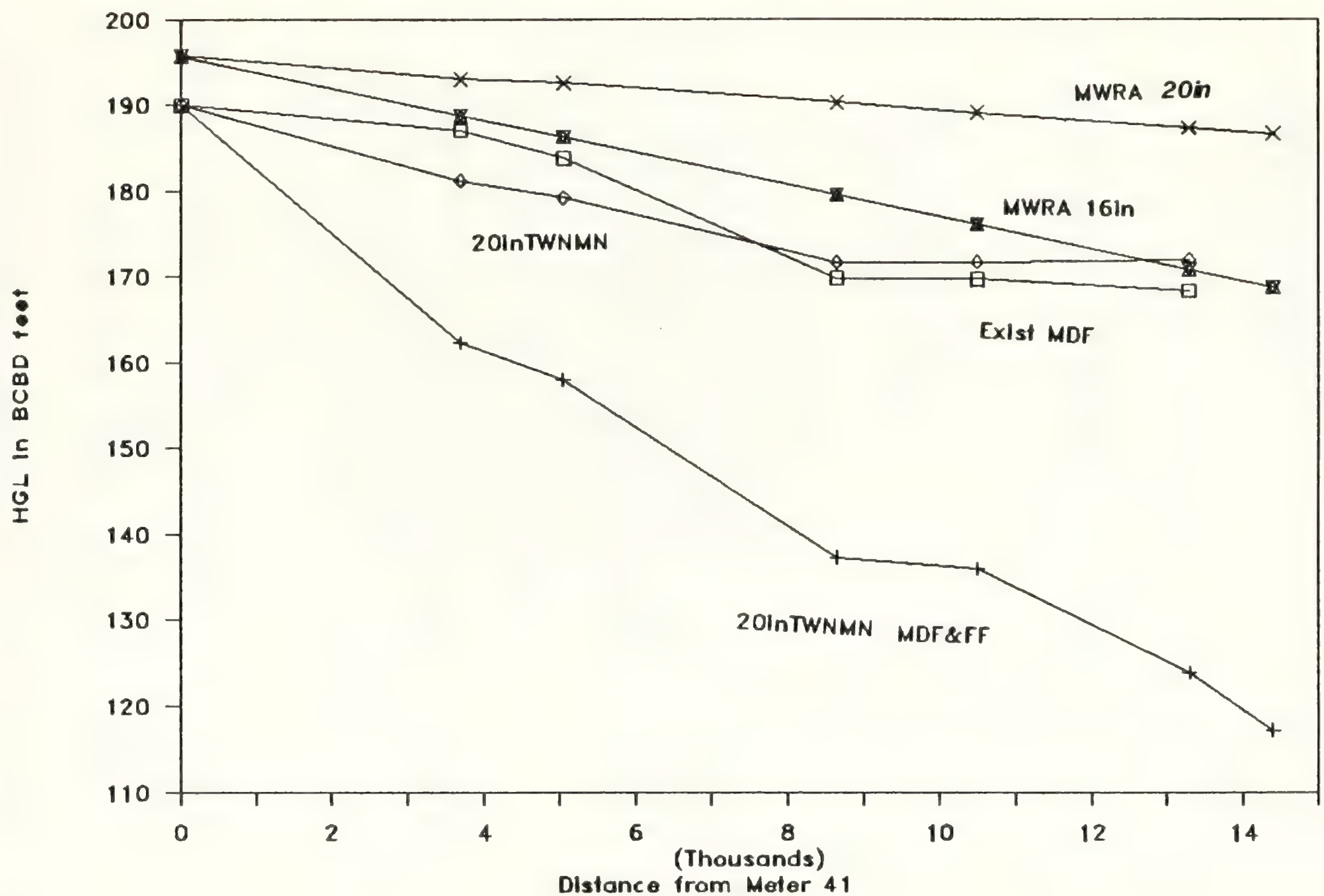

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FIGURE I-6
HGL FOR MAX DAY DEMANDS
(HGL OF ALTERNATIVES)

24 inch pipe at $90 per ft	=	$2,160,000
Dredging at $28 per yd^3	=	2,400,000
Backfill crushed stone at $7.90 per ton	=	836,000
Armor stone at $20 per ton	=	319,000
Other construction activities	=	1,200,000
		$6,915,000
approximately, therefore:		$7,000,000

The total installed cost based on the use of pipe capable of 15-degree deflection at each joint and suitable for subaqueous installation in soft bottom muds, along the route described above, is as follows:

24-inch pipe at $383 per ft	=	$ 9,200,000
All construction activities at $600 per ft(1)	=	14,400,000
		$23,600,000

(1) Empirical data for difficult subaqueous environments, S&W Estimating Department.

The two estimated prices in paragraph 6.3 differ primarily in the degree of conservatism employed and can, therefore, be said to define the range of probable costs. Although additional engineering would be required to refine the estimated cost for this alternative, the range of costs is such that it can be concluded that this alternative would be considerably more expensive than the overland route through Winthrop.

6.4 ANALYSIS OF THE EAST BOSTON ALTERNATIVE

Potential difficulties associated with the East Boston alternative include possible encroachment on a wetland north of Logan Airport, the need to obtain a dredging permit for the subaqueous portions of the route, disruption of traffic in East Boston during construction, the need to cross Route 1A and the Blue Line subway tracks northwest of Logan Airport, the crossing of a potential third harbor tunnel route, and the environmental impacts and expenses associated with excess dredge spoil disposal.

The procedure to perform construction within the vicinity of Logan Airport is to first have the project submit a request for permission to construct.

This request would then be reviewed by Massport and appropriate conditions attached. (This procedure is similar to the procedure an airport tenant, such as an airline, would follow.)

Massport and the Federal Aviation Administration (FAA) have established that runways are theoretically 1000-ft-wide with a 7:1 slope upwards from 500 ft off the centerline of the runway.

Within the airport there is a perimeter road, off the edge of the runway. This roadway is typically about 500 ft off centerline and would have to be kept open continuously. Construction equipment could not park on this roadway or construct within it. This would require that construction be outside of the roadway on the water side within the riprap or tide water areas.

During periods of poor visibility, no vehicles of any sort are allowed in the runway area or in the perimeter road area. All construction would have to cease.

Massport standard conditions restrict access to runways and adjacent areas. At the end of a runway, extra special provisions would be required, which would likely require some night work when planes are not flying.

It is unclear whether Massport regulations and review would require that a water main would have to be installed within a sleeve. As a minimum, sleeves are likely to be required at end of runways.

7.0 CONCLUSIONS REGARDING VARIOUS ALTERNATIVES

The apparent environmental and social impacts of the East Boston alternative, combined with its high price, make the Winthrop alternative more attractive.

Of the three Winthrop alternatives, the dedicated main, tied into Winthrop's existing distribution system, is considered the most attractive for the following reasons:

- It provides redundancy to both Deer Island and the Town of Winthrop.

- It is capable of supplementing pressure in Winthrop's distribution system should the need arise.

Secondary Treatment Facilities Plan

Volume III

Appendix J
Design Criteria

APPENDIX J

SUMMARY OF RECOMMENDED PLAN UNIT PROCESS SIZING

Table J-1 has been constructed to offer a quick reference to the sizing and equipment requirements of each recommended unit process and the design criteria used in sizing units and equipment. A summary of the equipment at the remote headworks is also included in the table. Odor/VOC control equipment and ancillary facilities appear in the table as well. For a more concise description of the units, the equipment, the flow scheme and interprocess conveyance refer to Section 11.0.

TABLE J-1

DEER ISLAND SECONDARY TREATMENT FACILITY
SUMMARY OF RECOMMENDED PLAN
UNIT PROCESS SIZING AND EQUIPMENT

I. REMOTE HEADWORKS

A. CHELSEA CREEK

1. MECHANICALLY CLEANED CLIMBER SCREENS

Number of Screens (includes 1 standby unit)	4
Bar Spacing	3/4 in
Screen Dimensions:	
Width	12 ft
Sidewater Depth (maximum)	6 ft 10 in

2. GRIT COLLECTION

Number of Channels (includes 1 standby unit)	4
Channel Dimensions:	
Width	24 ft 6 in
Length	88 ft
Sidewater Depth (maximum)	11 ft 4 in
Capacity, each	117 mgd

B. COLUMBUS PARK

1. MECHANICALLY CLEANED CLIMBER SCREENS

Number of Screens (includes 1 standby unit)	4
Bar Spacing	3/4 in
Screen Dimensions:	
Width	10 ft 6 in
Sidewater Depth (maximum)	6 ft

2. GRIT COLLECTION

Number of Channels (includes 1 standby unit)	4
Channel Dimensions:	
Width	20 ft
Length	58 ft 4 in
Sidewater Depth (maximum)	9 ft 8 in
Capacity, each	61 mgd

C. WARD STREET

1. MECHANICALLY CLEANED CLIMBER SCREENS

Number of Screens (includes 1 standby unit)	4
Bar Spacing	3/4 in
Screen Dimension:	
Width	10 ft 6 in
Sidewater Depth (maximum)	6 ft 6 in

2. GRIT COLLECTION

Number of Channels (includes 1 standby unit)	4
Channel Dimensions:	
Width	20 ft
Length	80 ft
Sidewater Depth (maximum)	10 ft 1 in
Capacity, each	85.3 mgd

D. WINTHROP TERMINAL

Number of Climber Screens (includes 1 standby unit)	3
Bar Spacing	7/8 in
Screen Dimension:	
Width	4 ft
Sidewater Depth (maximum)	10 ft 6 in
Capacity, each	62.5 mgd
Number of Pumps (includes 2 standby units)	6
Pump Capacity, each	32 mgd
Motor Horsepower	600 hp

II. NUT ISLAND - PRELIMINARY TREATMENT

A. CLIMBER SCREENS

Number of Units (includes 2 standby unit)	4
Bar Spacing	3/4 in
Channel Dimensions:	
Width	11.5 ft
Depth (maximum)	11.5 ft
Capacity, each	180 mgd
Velocity through Screen (maximum)	3 fps

B. CENTRIFUGAL GRIT CHAMBER

Number of Units (includes 1 standby unit)	6

Diameter	24 ft
Capacity, each	72 mgd
Total Number of Grit Slurry Pumps	
(includes 6 standby units)	12
Type of Pump	Vortex
Capacity, each	150 gpm
Horsepower	5 hp
Number of Cyclone Grit Concentrators	
(includes 2 standby units)	5
Size	12 in. dia.
Capacity, each	150 gpm
Number of Grit Washers (includes 2 standby unit)	5
Screw Size	12 in.

III. DEER ISLAND

A. PRELIMINARY TREATMENT

Number of Batteries	2
Number of Centrifugal Grit Chambers per battery	
(includes 1 standby unit per battery)	8
Diameter	24 ft
Capacity, each	74 mgd
Total Number of Grit Slurry Pumps	32
Number of Standby Pumps	16
Type of Pump	Vortex
Capacity, each	150 gpm
Horsepower	5 hp
Number of Cyclone Grit Concentrators	
(includes 4 standby units)	10
Size	12 in. dia.
Capacity, each	150 gpm
Number of Grit Washers	
(includes 3 standby units)	10
Screw size	12 in. dia.

B. PRIMARY TREATMENT

1. STACKED RECTANGULAR PRIMARY CLARIFIERS

Number of Batteries		4
Total Number of Stacked Sets per Battery		24
Number of Stacked Sets Required at Peak Flow		21
Number of Standby Stacked Sets		3
Tank Dimension:		
Effective Length:	Upper	181 ft

	Lower	191 ft
Width	(upper and lower)	20.5 ft
Sidewater Depth (minimum, upper and lower)		12.0 ft
Surface Area per Stacked Set		7,626 sf

Overflow Rate (not including standby tankage)

Peak Flow	2000 gpd/sf
Flow Receiving Only Primary Treatment	1200 gpd/sf

2. AERATED INFLUENT CHANNEL

Number per Battery	1
Channel Dimensions:	
Length	530 ft
Width	6 ft
Depth	18
Aeration Rate	3 scfm/1f
Number of Blowers per Battery (includes 1 standby unit)	2
Capacity, each	1600 scfm
Horsepower	100 hp

3. NON METALLIC CHAIN AND FLIGHT SLUDGE COLLECTORS

Number of Drives (one drive per two adjacent tanks)	96
Horsepower, per drive	0.5 hp

4. SLUDGE PUMPS

Total Number of Pumps	80
Number of Standby Pumps	32
Capacity, each	120 gpm
Horsepower	7.5 hp

5. SCUM PUMPS

Total Number of Pumps	8
Number of Standby Pumps	4
Capacity, each	900 gpm
Horsepower	40 hp

6. TRAVELING SCREENS FOR PORTION OF FLOW RECEIVING ONLY PRIMARY TREATMENT

Design Flow	190 mgd

Screen Bay	15 ft by 15 ft
Screens	
Number of Screens (includes 1 standby unit)	3
Type of Screen	Dual Flow
Width (nominal)	6 ft
Screen Mesh	1/4 in
Head Loss	< 1 ft
Velocity through Screen (maximum)	2 fps
Motor Horsepower	3 hp

Spray Water Pumps	
Number of Pumps (includes 1 standby unit)	2
Capacity, each	350 gpm
tdh	25 ft
Refuse Pumps	
Number of Pumps (includes 1 standby unit)	2
Capacity, each	350 gpm
tdh	25 ft

C. SECONDARY TREATMENT

1. ANAEROBIC SELECTOR BASINS

Number of Batteries	4
Number of Compartments Per Battery	4
Compartment Dimension:	
Length	64 ft
Width	90 ft
Sidewater Depth	18 ft
Freeboard	3 ft
Volume per Battery	3.1 mil gal
Hydraulic Retention Time (average high groundwater flow including average RAS)	20 min
Mixing Requirements	0.5 hp/1000 cf
Total Number of Mechanical Mixers (2 mixers per compartment)	32
Mixer Size	20 hp

2. AERATED INFLUENT CHANNEL

Number of Channels per Battery	1
Dimensions	
Length	128 ft
Width	14 ft
Sidewater Depth	14 ft

Aeration Rate	3 scfm/1f
Number of Blowers per battery (includes 1 standby unit)	2
Capacity, each	500 scfm
Horsepower	20 hp

3. AERATION BASINS

Number of Batteries	4
Number of Trains Per Battery	3
Number of Stages Per Train	4
Stage Dimension:	
Length	70 ft
Width	70 ft
Sidewater Depth	23.5 ft
Freeboard	5 ft
Volume per Battery	10.34 mil gal
Total Volume	41.34 mil gal
Total Number of Surface Aerators (with draft tubes)	48
Horsepower Stage 1	150 hp
Stage 2	100 hp
Stage 3	100 hp
Stage 4	100 hp
Hydraulic Retention Time (average high groundwater flow)	1.48 hr
F/M (based on BOD_r and MLVSS)	0.73 $days^{-1}$
SRT	2.3 days
MLSS	2000 mg/l
MLVSS	1600 mg/l
Oxygen Required per lb BOD removed	0.85 lb
Number of Purge Blowers per Battery (includes 1 standby unit)	2
Capacity	10,000 scfm
Motor Horsepower	50 hp

4. CRYOGENIC OXYGEN GENERATION WITH MOLECULAR SIEVE PREPURIFIER

Number of Units (1 in operation at any one time)	2
Capacity	300 tpd
Number of Compressors (each size with 1 standby unit)	4
2-100 percent capacity	3500 hp
2-70 percent capacity	2500 hp

LOX Storage	1000 tons
Number of Cooling Water Pumps	
(includes 2 pumps per system each with	
1 standby unit)	4
Capacity, each	1200 gpm
Horsepower	15 hp

5. STACKED RECTANGULAR SECONDARY CLARIFIERS

Number of Batteries	4
Total Number of Stacked Sets Per Battery	36
Number Stacked Sets Required at Peak Flow	32
Number of Standby Stacked Sets	4
Tank Dimension:	
Effective Length: Upper	160 ft
Lower	180 ft
Width: (upper and lower)	20.5 ft
Sidewater Depth:	
(minimum, upper and lower)	13 ft
Surface Area per Stacked Set	6970 sf
Overflow Rate (high groundwater average daily flow)	750 gpd/sf
(not including standby tankage)	
Aerated Influent Channel	
Length	420 ft
Width	6 ft
Depth	18 ft
Aeration Rate	3 scfm/1f
Number of Blowers per battery	
(includes 1 standby unit)	2
Capacity, each	2600 scfm
Horsepower	150 hp
Non Metallic Chain and Flight Sludge Collectors	
Number of Drives (one drive per two	144
adjacent tanks)	
Horsepower	0.5 hp
RAS Pumps	
Total Number of Pumps	20
Number of Standby Pumps	8
Capacity	30,000 gpm
Horsepower	300 hp
WAS Pumps	
Total Number of Pumps	20

Number of Standby Pumps	8
Capacity	500 gpm
Horsepower	7.5 hp
Scum Pumps	
Total Number of Pumps	16
Number of Standby Pumps	8
Capacity	700 gpm
Horsepower	40 hp

D. DISINFECTION - PURCHASED SODIUM HYPOCHLORITE

Number of Tanks	4
Number of Passes Per Tank	3
Pass Dimensions:	
Length	310 ft
Width	20 ft
Depth (peak flow)	24 ft
Total Volume	13.36 mg
Detention Time (peak flow)	15 min
Number of Storage Tanks	3
Capacity, each	250,000 gal
Storage Tank Dimension:	
Diameter	40 ft
Height	27 ft
Number of Metering Pumps	
(includes 3 standby unit with primary treatment)	13
Capacity	572 gal/hr
Number of Sodium Metabisulfide Pumps	
(includes 4 standby units)	18
Capacity	572 gal/hr

IV. ODOR/VOC CONTROL SYSTEM

A. NUT ISLAND

Air Flow	55,000 cfm
Number of Scrubbers	4
Diameter of Scrubbers	7 ft
Number of Fans	4
Fan Size	27,500 cfm
Motor Horsepower	125 hp
Number of Dual Bed Carbon Adsorbers	6

Bed Diameter	12 ft
Equipment Redundancy	100 percent

B. WINTHROP TERMINAL PUMP STATION

Air Flow	15,300 cfm
Number of Scrubbers	2
Diameter of Scrubbers	6 ft
Number of Fans	2
Fan Size	15,300 cfm
Motor Horsepower	75 hp
Numbers of Dual Bed Carbon Adsorbers	2
Bed Diameter	12 ft
Equipment Redundancy	100 percent
Building Dimensions	50' x 80' x 28'

C. SCREENING FACILITY

Air Flow	21,000 cfm
Number of Scrubbers	2
Diameter of Scrubbers	7 ft
Number of Fans	2
Fan Size	21,000 cfm
Motor Horsepower	100 hp
Number of Dual Bed Carbon Adsorbers	2
Bed Diameter	12 ft
Equipment Redundancy	100 percent
Building Dimensions	75' x 60' x 28'

D. PRELIMINARY AND PRIMARY TREATMENT

Two facilities are required. Each facility serves two batteries of grit chambers, primary clarifiers, influent channels, and maintenance exhaust. The West facility also serves grit classifier, South System Pump Station, and the primary splitter box.

East Facility

Air Flow	
Grit Chambers	19,000 cfm
Primary Clarifier/Influent Channel	32,600 cfm
Maintenance Exhaust	22,100 cfm
Scrubbers	
Grit Chambers	2 - 6 ft dia.
Primary Clarifier/Influent Channel	2 - 9 ft dia.

Maintenance Exhaust	1 - 7 ft dia.
Fans	
Grit Chambers	2 @ 19,000 cfm 100 hp each
Primary Clarifiers/Influent Channel	2 @ 32,600 cfm 150 hp each
Maintenance Exhaust	1 @ 22,100 100 hp
Carbon Adsorbers - Dual Bed	
Grit Chamber	2 - 12 ft dia.
Primary Clarifiers/Influent Channels	4 - 12 ft dia.
Maintenance Exhaust	1 - 12 ft dia.
Building Dimensions	80' x 125' x 30'

West Facility

Air Flow	
Grit Chamber	19,000 cfm
Primary Clarifier/Influent Channel	39,800 cfm
Grit Classifiers and Primary Maintenance	21,000 cfm
Scrubbers	
Grit Chamber	2 - 6 ft dia
Primary Clarifier/Influent Channel	2 - 9 ft dia
Grit Classifiers and Primary Maintenance	3 - 7 ft dia
Fans	
Grit Chamber	2 @ 19,000 cfm 100 hp each
Primary Clarifier/Influent Channel	2 @ 39,800 cfm 200 hp
Grit Classifiers and Primary Maintenance	3 @ 21,000 100 hp
Carbon Adsorbers - Dual Bed	
Grit Chamber	2 - 12 ft dia.
Primary Clarifier/Influent Channel	4 - 12 ft dia.
Grit Classifiers and Primary Maintenance	3 - 12 ft dia.
Building Dimensions	85' x 150' x 30'

E. Secondary Treatment

Two facilities are required. Each facility serves two batteries of selector

zones, oxygen basins and influent and effluent channels. The North facility also serves the secondary splitter box.

South Facility

Air Flow	18,000 cfm
Number of Scrubbers	2
Diameter of Scrubbers	5 ft
Number of Fans per Facility	2
Fan Size	18,000 cfm
Motor Horsepower	75 hp
Number of Dual Bed Carbon Adsorbers	2
Bed Diameter	12 ft
Equipment Redundancy	100 percent
Building Dimensions	50' x 80' x 28'

North Facility

Air Flow	21,000 cfm
Number of Scrubbers	2
Diameter of Scrubbers	7 ft
Number of Fans	2
Fan Size	21,000 cfm
Motor Horsepower	100 hp
Number of Dual Bed Carbon Adsorbers	2
Bed Diameter	12 ft
Equipment Redundancy	100 percent
Building Dimensions	50' x 80' x 28'

V. ANCILLARY FACILITIES

A. PLANT WATER

Required Average Flow	45 mgd
Number of Pumps (includes 2 standby units)	5
Pump Capacity @ 100 tdh	15 mgd

SECONDARY TREATMENT FACILITIES PLAN

VOLUME III
APPENDIX K
TRAFFIC

Table of Contents

1.0 Introduction

This appendix contains cumulative traffic projections for all of the activities occurring on Deer Island between 1988 and 1999. In addition, the Existing Traffic Environment, Treatment Facilities Transportation Impacts and the Construction Workers Satellite Parking Assessment prepared by PEER Consultants, P.C. are attached. The Existing Traffic Environment report addresses the existing traffic conditions in Winthrop, the intersection analysis and the traffic analysis methodology. The Treatment Facilities Transportation Impacts Report projects the worker and trucking estimates associated with the construction of preliminary, primary, secondary, disinfection and support facilities for the new Deer Island Secondary Treatment Facility. The Construction Workers Satellite Parking Assessment addresses the feasibility and impacts of busing construction workers from remote parking facilities to Deer Island. A Further evaluation of satellite parking and busing which considered the feasibility of additional satellite parking locations is entitled "Satellite Parking Study For Bus Transport From Revere, Chelsea, and Boston to Deer Island". The report was prepared by The BSC Group - Boston, Inc., and can be found in Appendix S of this volume.

2.0 CUMULATIVE TRANSPORTATION PROJECTIONS

Cumulative transportation projections for all known Deer Island and Nut Island MWRA construction activities, including the Deer Island Secondary Treatment Facilities are presented in Table K-1. Cumulative peak worker and truck volumes for Deer Island construction are presented in Figures K-1 and K-2 respectively. Construction of the facilities at Deer Island will commence in 1988 and will continue through 1999 while work at Nut Island will occur between 1988 and 1995. These projections include worker and truck requirements which have been examined for Early Site Preparation, Inter-island Wastewater Conveyance System, Treatment Facilities and the outfall (Site 5.0). Other activities occurring on Deer Island during this period are operation and maintenance of the existing treatment facilities, MWRA Fast Track project and the operation of the House of Correction. In addition, there are several other MWRA projects which will be occurring within this period of time. These projects include the Pier Projects, Interim Scum Project, Interim Sludge Project, Sodium Hypochlorite Disinfection, Trunk Sewer rehabilitation, Interim Residuals Management and Final Residuals Management. The preliminary traffic volumes used to identify cumulative traffic were calculated using the following information or sources:

- o Fast Track - (Havens & Emerson, 1987)

TABLE K-1
CUMULATIVE DAILY TRAFFIC MOVEMENTS
MWRA SECONDARY TREATMENT FACILITIES PLANNING

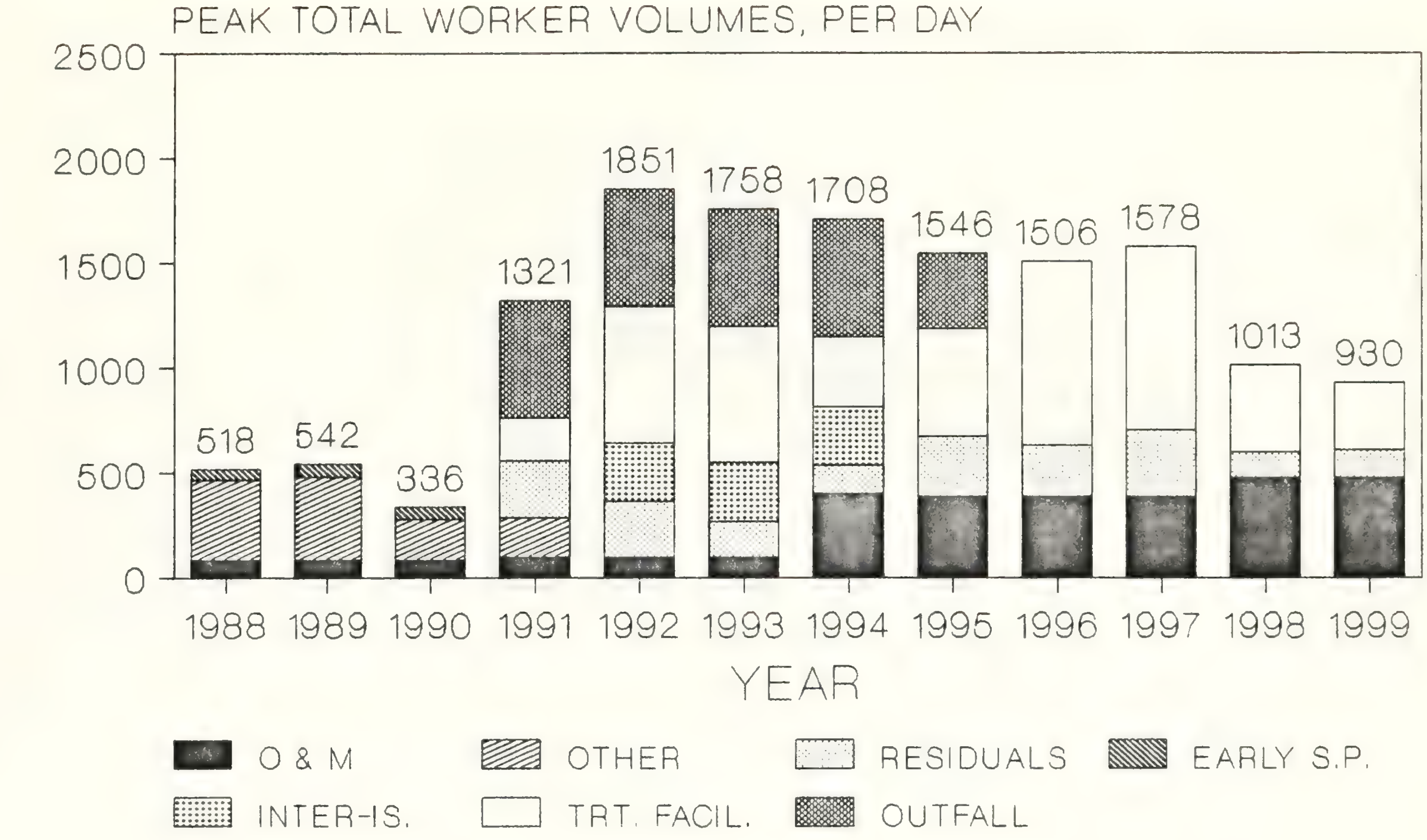
	YEAR	DEER ISLAND WORKERS AVERAGE	PEAK	NUT ISLAND WORKERS AVERAGE	PEAK	DEER ISLAND TRUCKS AVERAGE	PEAK	NUT ISLAND TRUCKS AVERAGE	PEAK
OTHER PROJECTS:									
Fast Track	1988	81	117			10	15		
	1989	81	117			10	15		
Piers	1988	63	100	41	70	4	12	4	12
	1989	63	100	41	70	4	12	4	12
House of Correc.	1988	148	148						
	1989	148	148						
	1990	148	148						
	1991	148	148						
Interim Scum	1988	5	6	13	20	-	1	7	10
Interim Sludge/ Residuals	1989			47	62			-	1
	1990	31	41	47	62	6	13	-	1
	1991	31	41			6	13		
Conv. to NAOCl	1989	20	25			2	5		
Trunk Sewer Rehab.	1988	4	5						
OPERATIONS AND MAINTENANCE:									
	1988	84	87	74	81	18	22	9	10
	1989	84	87	76	83	17	20	9	10
	1990	84	87	86	93	17	20	9	10
	1991	94	97	86	93	17	20	9	10
	1992	94	97	86	93	17	20	9	10
	1993	94	97	86	93	17	20	9	10
	1994	358	403	86	93	17	20	9	10
	1995	377	391	10	15	13	15		
	1996	377	391	10	15				
	1997	377	391	10	15				
	1998	440	480	10	15				
	1999	461	480	10	15				

YEAR	DEER ISLAND WORKERS AVERAGE	PEAK	NUT ISLAND WORKERS AVERAGE	PEAK	DEER ISLAND TRUCKS AVERAGE	PEAK	NUT ISLAND TRUCKS AVERAGE	PEAK
RESIDUALS 1 AND 2:								
1991	208	270			5	10		
1992	203	264			5	10		
1993	132	171			5	10		
1994	100	130			5	10		
1995	210	280			5	10		
1996	180	240			5	10		
1997	232	312			5	10		
1998	90	118			5	10		
1999	100	130			5	10		
EARLY SITE PREPARATION								
1988	41	55			2	3		
1989	46	65			2	3		
1990	26	60			2	3		
INTER-ISLAND WASTEWATER CONVEYANCE SYSTEM:								
1992	81	280			13	25		
1993	265	280	20	30	25	25	5	5
1994	185	280			20	25		
TREATMENT FACILITIES								
1991	155	205			5	5		
1992	495	650	55	70	45	55	10	20
1993	495	650	55	70	45	55	10	20
1994	255	335	55	70	30	35	10	20
1995	395	515	55	70	35	39	10	20
1996	670	875			35	64		
1997	670	875			35	60		
1998	320	415			20	39		
1999	245	320			15	20		
OUTFALL (SITE 5.0)								
1991	165	560			32	85		
1992	560	560			85	85		
1993	560	560			85	85		
1994	560	560			77	85		
1995	360	360			15	15		

YEAR	DEER ISLAND WORKERS AVERAGE	PEAK	NUT ISLAND WORKERS AVERAGE	PEAK	DEER ISLAND TRUCKS AVERAGE	PEAK	NUT ISLAND TRUCKS AVERAGE	PEAK

TOTAL OF ALL PROJECTS, INCLUDING OPERATIONS & MAINTENANCE:

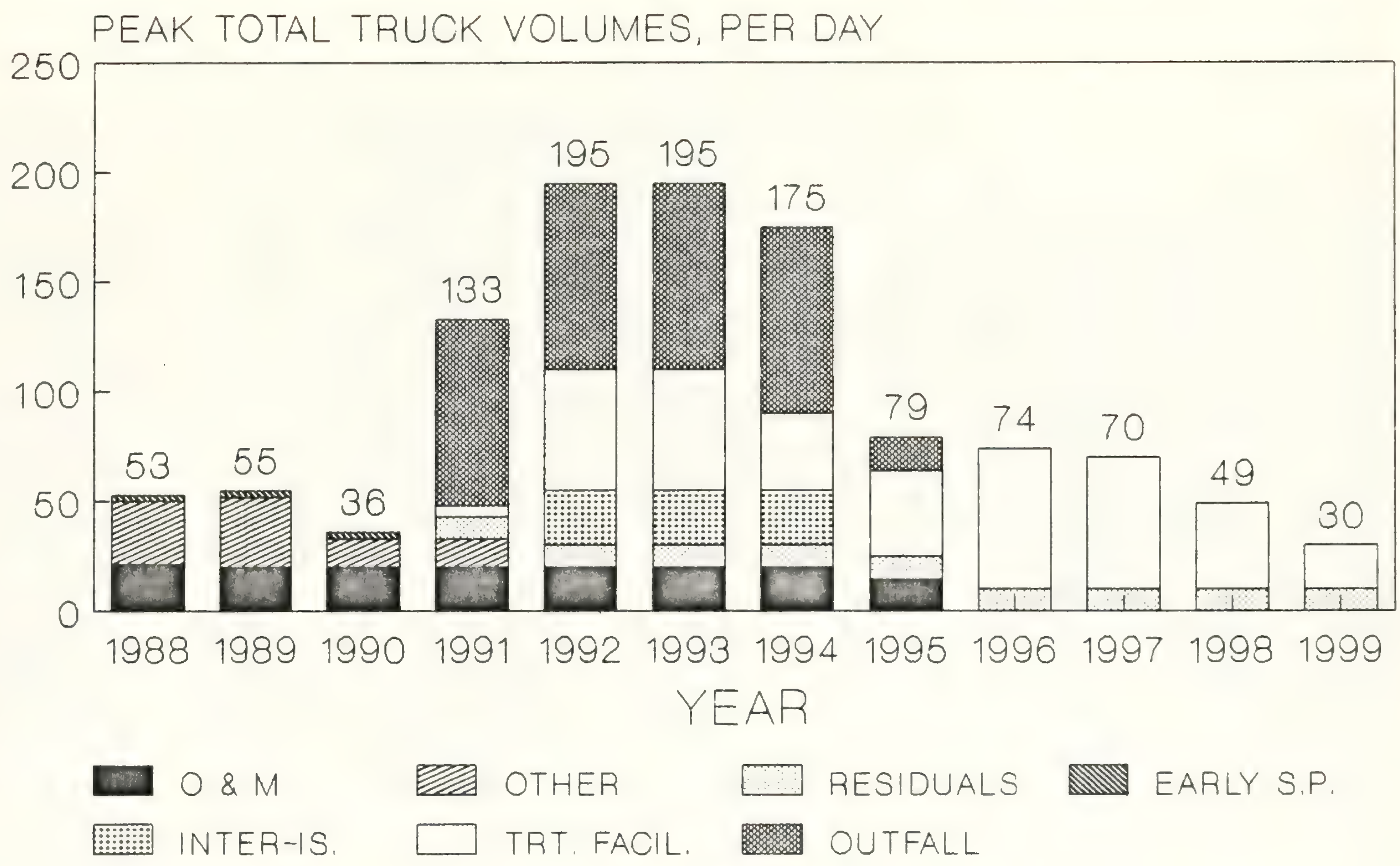
YEAR	DEER ISLAND WORKERS AVERAGE	PEAK	NUT ISLAND WORKERS AVERAGE	PEAK	DEER ISLAND TRUCKS AVERAGE	PEAK	NUT ISLAND TRUCKS AVERAGE	PEAK
1988	426	518	128	171	34	53	20	32
1989	442	542	164	215	35	55	13	23
1990	289	336	133	155	25	36	9	11
1991	801	1,321	86	93	65	133	9	10
1992	1,433	1,851	141	163	165	195	19	30
1993	1,546	1,758	161	193	177	195	24	35
1994	1,458	1,708	141	163	149	175	19	30
1995	1,342	1,546	65	85	68	79	10	20
1996	1,227	1,506	10	15	40	74		
1997	1,279	1,578	10	15	40	70		
1998	850	1,013	10	15	25	49		
1999	806	930	10	15	20	30		



OTHER PROJECTS = FAST TRACK, PIERS,
HOUSE OF CORREC, INT SCUM, INT SLUDGE
NaOCl CONV, AND TRUNK SEWER

MASSACHUSETTS WATER RESOURCES AUTHORITY

FIGURE K-1
CUMULATIVE PEAK WORKER TRAFFIC TO DEER ISLAND



OTHER PROJECTS = FAST TRACK, PIERS
HOUSE OF CORREC, INT SCUM, INT SLUDGE,
NaOCl CONV, AND TRUNK SEWER

MASSACHUSETTS WATER RESOURCES AUTHORITY	**FIGURE K-2** **CUMULATIVE PEAK TRUCK TRAFFIC TO DEER ISLAND**

- o Piers - Facilities Plan and EID Volume 7 On-Island Water Transportation Facilities (October, 1987)
- o House of Correction - Numbers estimated by MWRA.
- o Interim Scum - Deer Island numbers based upon an estimated $100,000 project cost. Nut Island numbers estimated by MWRA.
- o Interim Residuals/Sludge - Deer Island numbers based upon an estimated $4M project cost. Nut Island numbers based upon an estimated $3M project cost.
- o Sodium Hypochlorite Disinfection - Numbers estimated by MWRA.
- o Trunk Sewer - Numbers estimated by MWRA.
- o Residuals 1 and 2 - Numbers based upon an estimated $252M project cost.

Typical construction breakdowns were used to project worker and truck volumes from estimated project costs. Traffic volumes associated with these projects are included in the cumulative totals.

The highest worker volumes at Deer Island will occur between 1992 and 1997 which corresponds to the overlapping of peak construction periods for the treatment facilities, the outfall and the inter-island conveyance system. The average number of workers range from 289 to 1,546 per day and the peak number of workers range from 336 to 1,851 per day during the construction period. At Nut Island, the highest worker and worker vehicle volumes occur in 1989 and between 1992 and 1994. The average number of workers ranges from 10 to 164 per day and the peak ranges from 15 to 215 per day. Approximately 50% of the volumes at Nut Island are attributable to operations and maintenance personnel which decreases significantly in 1995 when treatment operations end.

The highest truck volumes at Deer Island will occur between 1992 and 1994. The average number of trucks will range from 20 to 177 per day and the peak number of trucks will range from 30 to 195 per day. Truck volumes associated with work at Nut Island will range from 9 to 35 per day between 1988 and 1995. All materials movements have been uniformly estimated on the basis of a unit truck shipment. Upon completion of the piers in 1991, all materials and equipment, with the exception of contingency trucking of 8 vehicles per day, will be transported to the site over water. The bulk materials required for facility construction, such as cement and aggregate, will be loaded on to barges at

docking facilities close to supply sources for over-water transport to the bulk handling pier facilities at Deer Island and Nut Island.

In addition, with the completion of the pier facilities in 1991, a minimum of half of all workers will be ferried to Deer Island from remote docking facilities. This is described in more detail in the Facilities Plan and Environmental Information Document for On-Shore Water Transportation Facilities. The remainder of the workers will be transported to the site by bus from satellite parking areas. Satellite parking is summarized in Section 11.4.4 of this report; detailed considerations of satellite parking are included in this appendix and in Appendix S.

It is expected that the majority of construction work will be a two shift operation with the exception of inter-island tunnel and effluent tunnel boring and lining, which will be by three and four eight-hour shifts respectively. Plant operation and maintenance and House of Correction workers will work three shifts. The highest worker volumes at Deer Island are from 1992 trough 1997; however, there is not a direct correlation with the overall worker volumes and worker shift change volumes. The peak worker shift change volume is in the third quarter of 1996; the overall peak worker volume is in the first quarter of 1995. Critical time periods for worker shift change volumes are 1992 to mid-1993 and 1995 through 1997. The maximum number of workers needing parking at the satellite parking facilities, which are described subsequently, will be during these times and are defined by the arrival of one shift and departure of another. The recommendations for satellite parking provide for an adequate number of parking spaces to accommodate these vehicles at the facilities.

MASSACHUSETTS WATER RESOURCES AUTHORITY

Winthrop MA Existing Traffic Environment

Transportation Impacts and Mitigation

March 1988

PEER Consultants, PC

Philadelphia, PA

MASSACHUSETTS WATER RESOURCES AUTHORITY

Winthrop MA Existing Traffic Environment

Transportation Impacts and Mitigation

The paragraphs below summarize the existing traffic environment in Winthrop Massachusetts. Intersection service level analyses have been performed for selected Winthrop intersections to ascertain the current Level of Service at each intersection. The results of these analyses are also summarized. Possible mitigation measures that could be employed to minimize impacts that could result from Deer Island wastewater treatment plant construction traffic movements through Winthrop are described. The discussion begins, however, with a summary of findings.

Mainland access to Deer Island is through Winthrop, MA. Field observations of the existing traffic environment have shown that local roadways are narrow and that vehicular movements are generally dispersed, irregular and at moderate speeds. Field observations have also shown that peak conditions have a very short duration in Winthrop. A peak hour can be identified in the morning and afternoon, however, truly peak conditions exist only for a 20-minute period in each case. On average, significant queues do not develop at intersections in Winthrop.

A route for truck movements through Winthrop to Deer Island has already been established. The route avoids the town center but passes through the majority of Winthrop. A limiting factor is that the Saratoga Street Bridge carries a load limit restriction of 33 tons.

Intersection Level of Service analyses have been performed for ten intersections that could be affected by increased vehicle movements. Intersections are generally the limiting factor for arterial capacities; Level

of Service analysis shows the vehicle capacity capabilities and expected vehicular delays of an intersection. Analyses were performed using computer methods based on American traffic engineering practice. The intersections were analyzed under existing peak hour conditions. All intersections were analyzed assuming phased signal control, some have also been analyzed as unsignalized where applicable.

The analyses show that installation of phased traffic signals at uncontrolled intersections and setting blinking signals to phased control will mitigate potential impacts of increased construction truck and worker movements to and from Deer Island. Phase-controlled intersections also will help assure the safe movement of vehicles through Winthrop.

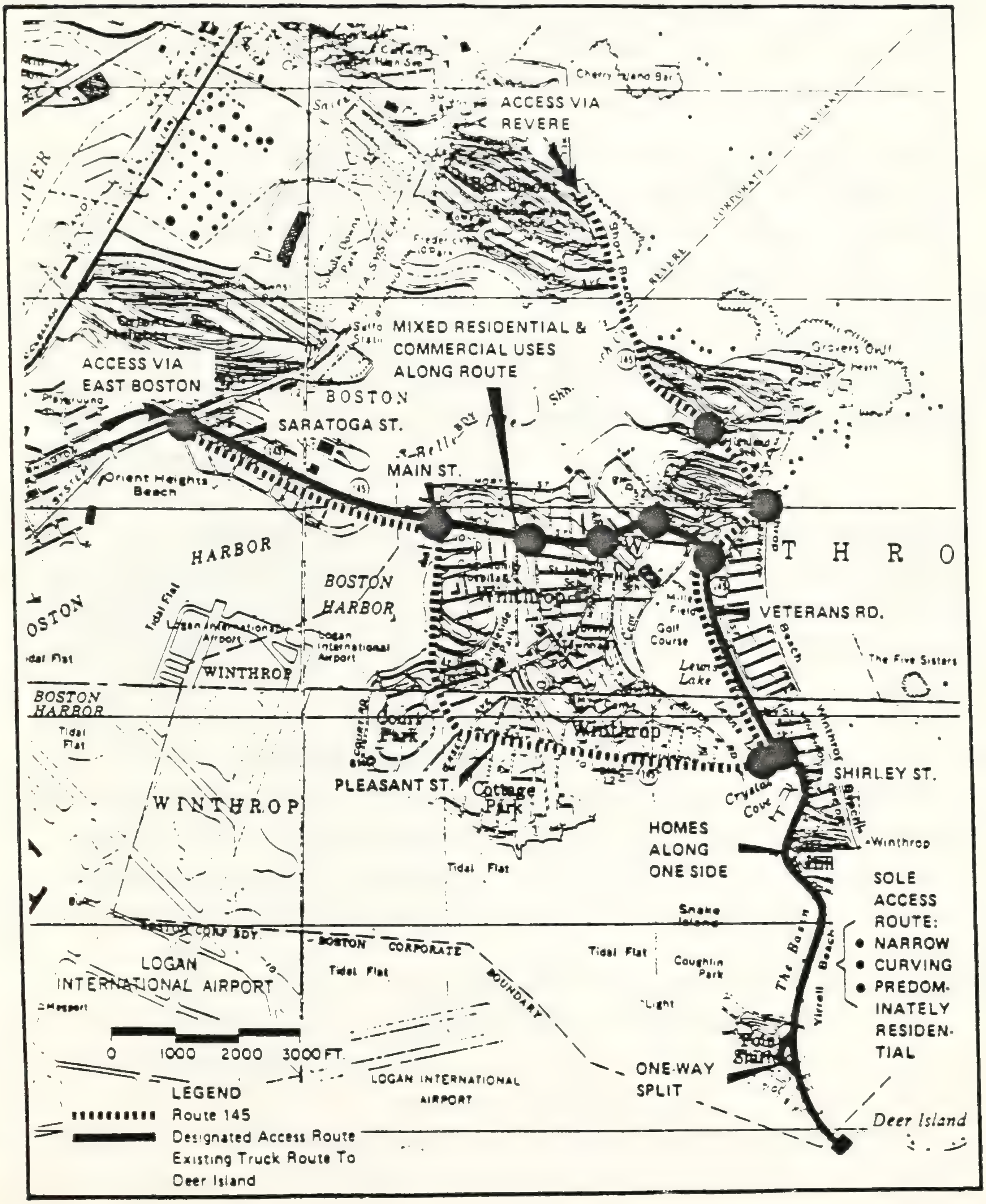
EXISTING TRAFFIC ENVIRONMENT

Land access to Deer Island is by a causeway that connects the island to the mainland. The island is within the corporate boundary of Boston; however, access to the causeway is by local roads passing through the Town of Winthrop.

Figure 1 shows a location map of Winthrop. Route 145 does not pass through the central part of town where the downtown business district and town hall are located, but rather circumnavigates it. The route provides general access from the north and west, over Bennington Street, Saratoga Street, Main Street, Pleasant Street, Washington Avenue, Veterans Road, Winthrop Shore Drive, Crest Avenue and Revere Street. On the western side, the crossing of Belle Isle Inlet leads to East Boston. On the northern side, a similar crossing leads to the town of Revere.

Figure 1

Winthrop, MA Location Map



A truck route has been defined and is posted, requiring that truck movements into and out of Winthrop, and to Deer Island and back, use Bennington Street, Saratoga Street, Main Street, Revere Street, Shirley Street, Veterans Road, Washington Avenue and Shirley Street. This route also avoids passage through the town center. Current truck movements over the defined route often occur with police escort.

Restrictions affecting use of the truck route include load limits on the bridge carrying Saratoga Street over the MBTA Blue Line. The bridge is currently limited to 2-axle trucks that are 13 tons or less, 3-axle trucks that are 20 tons or less and 5-axle trucks that are 33 tons or less.

Curbside parking is allowed along Main Street, Revere Street, Shirley Street and the lower section of Shirley Street The entire truck route supports two-way traffic flow; no one-way routing has been used to achieve higher throughput.

Local roadways elsewhere in Winthrop are fairly narrow, and there are few restrictions on curbside parking. Observed vehicular movements are dispersed and irregular. Only rarely is traffic movement delayed while a moving vehicle enters the opposing lane to avoid a parked vehicle occupying the moving lane.

Field observations of general traffic conditions in Winthrop have shown that vehicular speeds in Winthrop are between 20 and 30 mph and appear to be a matter of local habit and preference rather than a result of deliberate enforcement policies. Observed speeds over the entire truck route are moderate, serving to reduce congestion and preserve safety along the route.

Eight intersections along the current truck route that would be affected by truck movements to and from Deer Island have been identified. These intersections are:

1) Bennington Street and Saratoga Street - phased signal.

2) Main Street and Pleasant Street - phased signal.

3) Main Street and Hermon Street - phased signal.

4) Main Street, Revere Street, Winthrop Street - phased signal (blinking).

5) Revere Street and Shirley Street - phased signal (blinking).

6) Shirley Street and Veterans Road - blinking signal.

7) Veterans Road and Washington Avenue - no signal.

8) Washington Avenue and Shirley Street - no signal.

Two additional intersections have been identified that could be affected by construction worker vehicle traffic movements to and from Deer Island. These are:

1) Crest Avenue and Revere Street - blinking signal.

2) Veterans Road and Winthrop Shore Drive - no signal.

Field observations of the affected intersections in Winthrop showed that significant queues on average do not develop, with the exception of the two intersections along Main Street having phased signal control. These were at Hermon Street and Pleasant Street. Elsewhere, queues of no more than 6 vehicles are the rule; and all of these rapidly clear the intersection crossings.

During peak periods, queues accumulated at the approach stop lines were dissipated within the available green intervals, in all cases except one. The left turn out of Pleasant Street into Main Street westbound did not clear in the morning peak 20 minutes.

Peak conditions have only a very short duration in Winthrop. Observations have shown that the peak hour in the morning can reasonably be identified as between 6:30 and 7:30 AM; however, peak conditions really only exist during the 20 minutes between 6:50 and 7:10 AM. The same is true in the afternoon. The peak hour lasts from 5:00 to 6:00 PM, although truly peak conditions extend over only 20 minutes between 5:20 and 5:40 PM.

Accident history data taken over a six year period were obtained from the Massachusetts Department of Public Works for the intersections. Table 1 provides a summary of these data for the 10 intersections. The data show a majority of accidents involved two vehicles in traffic and either rear or angle collisions. Injuries were present in 81 out of the 373 accidents; there were no fatal accidents.

The Bennington and Saratoga Streets and the Main and Pleasant Streets intersections show a combined total of 162 accidents over a 4 year period. These two intersections serve as main entry points into Winthrop. Three additional intersections showing a relatively high number of accidents are the Main Street, Revere Street, and Winthrop Avenue, the Shirley Street and Veterans Avenue, and the Revere and Shirley Streets intersections. All three of these intersections are currently controlled by flashing signals. Of the unsignalized intersections, Shirley Street and Washington Avenue, an intersection having commercial businesses on each corner, shows the highest accident rate with 26 accidents occuring within the six year period.

METHOD OF ANALYSIS

The volume of traffic that can pass over a given roadway is largely a function of the speed at which traffic moves. Given normal driver reaction, speeds decline as traffic volume increases; maximum throughput usually occurs at speeds ranging from 30 to 40 mph.

Determinants of capacity vary for different types of facilities. In general, freeway capacity is a function of lane width, number of lanes provided, availability of improved shoulders and sight lines. For arterials, capabilities at intersections where conflicting movements can occur are usually the determinant of capacity; this is especially true in heavily-travelled corridors. Under principles of analysis established through the work of the Transportation Research Board, the maximum volume that can occur under the conditions described above is generally taken as representing the capacity of the particular facility under examination.

Table 1
Accident History Summary

INTERSECTION	TOTAL ACCDNTS	ACCDNTS W/ INJRY	ACCDNTS W/ FATAL	VHCLS INVLVD PER ACCIDENT 1	2	3	>4	INJURY NMBR PER ACCIDENT 1	2	3	>4	MOTOR VHCL COLLISION WITH: PED	MVNG VHCL	PRKD VHCL	OBJCT OFF-RD	OBJCT BY-RD	OTHR	COLLISION TYPE REAR	ANGL	HEAD	OTHR	TRAFFIC CONTROL TYPE STP SGN	WRNG SGN	SGNL	NO SGNL	NO CNTRL	OTHR
BENNINGTON/SARATOGA	101	21	0	7	83	10	1	14	5	2	0	4	71	16	2	1	7	33	47	2	19	3	0	61	1	35	1
MAIN/PLEASANT	61	10	0	2	54	1	2	6	4	0	0	0	53	3	1	2	2	28	21	3	9	3	0	37	0	20	1
MAIN/HERMON	13	4	0	3	7	1	2	2	1	1	0	1	7	1	0	1	3	3	6	1	3	1	0	7	0	5	0
MAIN/REVERE/WINTHROP	47	9	0	10	35	1	1	7	2	0	0	2	28	7	2	1	7	13	23	1	10	1	3	22	0	19	5
REVERE/SHIRLEY	26	8	0	4	21	0	1	8	0	0	0	2	18	3	2	0	1	5	14	1	6	4	2	10	0	10	2
SHIRLEY/VETERANS	39	9	0	0	35	3	1	6	3	0	0	0	32	4	0	0	3	4	28	1	6	20	0	9	0	10	0
VETERANS/WASHINGTON	5	2	0	2	2	0	1	2	0	0	0	1	0	3	0	0	1	2	1	0	2	0	0	0	0	5	0
WASHINGTON/SHIRLEY	26	7	0	2	23	1	0	6	0	1	0	1	15	6	1	0	3	5	19	0	2	3	0	0	0	22	1
VETERANS/WNTHRP SHR	4	0	0	0	4	0	0	0	0	0	0	0	3	0	1	0	0	0	3	0	1	3	0	0	0	1	0
CREST/REVERE/HIGHLAND	51	11	0	3	45	3	0	9	2	0	0	0	41	3	1	1	5	14	24	4	9	27	0	0	0	23	1
TOTALS	373	81	0	33	309	20	9	60	17	4	0	11	268	46	10	6	32	107	186	13	67	65	5	146	1	150	11

*ACCIDENT DATA IS TAKEN FROM MA DPW COMPUTER PRINTOUTS FOR TIME PERIODS OF 01/01/75 - 12/31/80 AND 01/01/83 - 12/31/83.

The potential impact on particular intersections in Winthrop that will be affected most directly by the Deer Island construction traffic has been examined, to establish whether new intersection delay could cause significant local distress. The purpose in these assessments has been to identify potential changes of service level at intersections.

Because of the need for recognition of local traffic conditions in estimates of highway performance, the Transportation Research Board in 1965 adopted a defined series of Service Levels that could be used in comparative assessments of the degree to which highway facilities accommodate traffic. These Levels of Service have had wide acceptance and application since 1965.

To measure the performance of existing or proposed highway facilities, the ratio of projected volume to available capacity has been commonly used. The numerator and denominator of this ratio are usually measured in terms of hourly vehicular flows, and a value of unity for the ratio is accepted as an indication that traffic volume fills the available capacity of a facility. Ratios larger than unity imply traffic volume in excess of available capacity, moving under forced flow conditions at slow speed. A ratio having a value less than unity means that volume has not yet reached capacity and that more acceptable traffic conditions prevail.

In 1985, the Transportation Research Board issued a revised Highway Capacity Manual that expanded the above service level definition to include vehicular delay concepts for signalized intersections as well as a procedure for use in estimating service levels at unsignalized intersections. A brief discussion of the methods contained in the 1985 Highway Capacity Manual is presented in the paragraphs below.

Signalized intersection performance is currently measured using both vehicular capacity and delay concepts. The capacity of an intersection and its associated delays are dependent on the intersection geometry, signal phasing, volume and pattern of traffic movements, and other factors such as the presence of curbside parking and pedestrian traffic. Both capacity and delay must now be examined for a complete assessment of the intersection.

The intersection capacity is derived by multiplying an established ideal intersection saturation flow rate with adjustment factors that account for lane width and number, heavy vehicles present, grade, parking maneuvers, bus blockage, area type, right turns and left turns. The adjusted value is then multiplied by the ratio of green time available for the movement in question to total cycle length to obtain approach capacity. The result is related to the volumes present in the form of a ratio of volume to capacity, (V/C).

The parameter of interest is the critical V/C ratio for the intersection. The critical V/C ratio indicates the proportion of available capacity in use by vehicles occupying critical lane groups. In general, the critical lane group is the lane or lanes moving during a phase that generates the highest ratio of flow rate to adjusted saturation flow, (V/S). The critical V/S ratios for each phase are summed, and then multiplied by the signal cycle length. This value is then divided by the cycle length minus the cycle time portion where movement is not allowed on any intersection approach, to yield the critical V/C ratio.

A critical V/C ratio of less than 1.00 indicates that the intersection geometry, cycle length and phase plan are adequate to handle all critical flows without demand exceeding capacity. A ratio greater than 1.00 indicates intersection changes may be warranted because of oversaturation conditions.

Intersection service level is related to the average stopped delay per vehicle. Delay is a function of cycle length, available green time, the V/C ratio and capacity. The level of service can be defined for lane groups within an approach, for each approach and for the entire intersection. The relation of service level to vehicular delay is shown in Table 2.

Table 2

Signalized Intersection Service Level Criteria

Level of Service	Stopped Delay per Vehicle (secs)
A	0.0 to 5.0
B	5.1 to 15.0
C	15.1 to 25.0
D	25.1 to 40.0
E	40.1 to 60.0
F	60.1 and greater

In the absence of congestion, the expected value of stopped delay obtained from the 1985 methods is dependent primarily on the signal cycle and phasing. The resultant level of service thus can be improved within limits by adjustments of signal timing and is not solely a reflection of traffic volume.

Capacity at unsignalized intersections is controlled by the distribution of gaps in the major street traffic stream and driver judgement in selecting gaps for executing desired maneuvers. The analysis method is based on the following criteria:

1) Major street traffic is generally not affected by minor street flows in uncongested traffic.

2) Where congestion does occur, it is likely that major flows will experience some impedance from minor street traffic.

3) Left turns from the major street are affected by the opposing major street flow.

4) Minor street traffic is affected by all major street movements and conflicting movements.

The method also adjusts for additional impedance of minor street flows on each other, and accounts for shared use of lanes. The method presumes that intersection control is provided on the minor street; this presumption has been used in the analysis.

Intersection service level is a function of the calculated reserve capacity for each lane of the minor street intersection approaches, and for approach left turn movements on the major street. An overall service level is not defined for unsignalized intersections. Table 3 shows service level criteria for unsignalized intersections.

Table 3

Unsignalized Intersection Service Level Criteria

Reserve Capacity (pssngr cars/pr hr)	Level of Service	Expected Delay to Minor Street Traffic
400 and greater	A	Little or no delay
300-399	B	Short traffic delays
200-299	C	Average traffic delays
100-199	D	Long traffic delays
0- 99	E	Very long traffic delays
*	F	*

*When demand exceeds the capacity of the lane, extreme delays will be encountered with queuing which may cause severe congestion affecting other traffic movements in the intersection.

The Transportation Research Board Levels of Service represent qualitative standards of the overall ability of defined highway facilities to satisfy motorists' desires at different times of the day and in relation to various levels of average operating speed, safety, freedom of maneuver, traffic mix and operating cost. Standard Levels of Service have been defined for limited-access facilities and for urban and rural arterials. The requirements for the several Levels of Service give recognition to the number of lanes available for travel, degree of intersection interference, lane width and other aspects of highway geometry and control.

In general, the defined Levels of Service A, B, and C describe traffic volumes, that are sufficiently low as to provide free and stable flow of traffic at attractive operating speeds. Service Level D usually describes a volume for given facilities that would cause unstable flow conditions to be approached, at reduced and less attractive operating speeds. Service levels E and F usually connote excessive volumes, unstable or forced flow conditions, high levels of delay and unattractive operating speeds.

Computer-based methods of analysis have been used, allowing specific consideration of the magnitude and composition of traffic flows from each

approach entering an intersection. Specific 15-minute peaking relationships are recognized for each approach. Estimates of capacity, the ratio of volume to capacity, service level and delay have been prepared for each lane group at each intersection, and for each intersection as a whole.

Through iterative application of the analysis to existing conditions and to conditions that will exist with the new plant under construction, the differential impact that will be experienced at each location as a result of the change in truck flows has been identified.

The methods used in the analysis are completely consistent with American traffic engineering practice. The details of method and data applied in each case are set forth in a description of the investigations performed for each intersection that appears later in this report.

INTERSECTION ASSESSMENTS - WINTHROP, MA

Intersection traffic volumes and turning movements were estimated using existing traffic count data. Turning movement count data collected during previous studies for the morning and afternoon peak periods showed that the critical hour in Winthrop occurs in the afternoon peak period. Turning movement counts were available for six of the intersections, additional afternoon peak period counts were made for the remaining four intersections. Signal phasing and intersection geometry data were obtained from the Massachusetts Department of Pubic Works and the Town of Winthrop.

The following computed estimates have been made for each intersection:

1) Service Level for each intersection lane group.
2) Service Level for the intersection as a whole.
3) Delay in seconds per vehicle for each intersection lane group.
4) Delay in seconds per vehicle for the intersection as a whole.

All estimates have been developed assuming no change of existing cartway widths, curbside parking practice or signal phasing. In cases where the intersection is operating as unsignalized, the intersections have been further analyzed under phased control. Details pertaining to each intersection examined are discussed below.

1) Main and Pleasant Streets - HMM Associates traffic data collected on 11 September 1985 show that the peak hour at this location occurs between 5:00 and 6:00 PM. The largest peak-hour volumes occur on the eastbound Main Street approach. The total peak-hour volume is 1,757 vehicles; the signal cycle time is 94 seconds.

2) Main and Hermon Streets - PEER Consultants traffic data collected on 4 September 1987 show that the peak hour at this location occurs between 4:45 PM and 5:45 PM. The largest peak-hour volumes occur on the Main Street eastbound and westbound approaches. The total peak-hour volume is 990 vehicles; the signal cycle time is 78 seconds.

3) Main, Revere and Winthrop Streets - HMM Associates traffic data collected on 12 September 1985 show that the peak hour at this location occurs between 5:00 and 6:00 PM. The largest peak-hour volumes occur on the eastbound Main Street and westbound Revere Street approaches. The total peak-hour volume is 1,386 vehicles; the signal cycle time is 79 seconds.

4) Revere and Shirley Streets - PEER Consultants traffic data collected on 10 July 1987 show that the peak hour at this location occurs between 5:00 and 6:00 PM. The largest peak-hour volumes occur on the eastbound Revere Street

aprroach. The total peak-hour volume is 1,392 vehicles; the signal cycle time is 68 seconds. This intersection is currently controlled using blinking lights, movements on Revere Street in both directions are controlled by yellow flashers and movements on Shirley Street are controlled by a red flasher.

5) Shirley Street and Veterans Road - HMM Associates traffic data collected on 11 September 1985 show that the peak hour at this location occurs between 5:00 and 6:00 PM. The largest peak-hour volumes occur on the eastbound Shirley Street approach. The total peak-hour volume is 605 vehicles; the intersection is currently controlled by a blinker with no provision for phased signaling.

6) Veterans Road and Washington Avenue - HMM Associates traffic data collected on 12 September 1985 show that the peak hour at this location occurs between 5:00 and 6:00 PM. The largest peak-hour volumes occur on the eastbound and westbound Washington Street aprroaches. The total peak-hour volume is 796 vehicles; the intersection is currently unsignalized.

7) Washington Avenue and Shirley Streets - HMM Associates traffic data collected on 11 September 1987 show that the peak hour at this location occurs between 5:00 and 6:00 PM. The largest peak-hour volumes occur on the eastbound Washington Avenue and northbound Shirley Street approaches. The total peak-hour volume is 823 vehicles; the intersection is currently unsignalized.

8) Veterans Road and Winthrop Shore Drive - PEER Consultants traffic data collected on 8 July 1987 show that the peak hour at this location occurs between 4:30 and 5:30 PM. The largest peak-hour volumes occur on the southbound Winthrop Shore Drive aprroach. The total peak-hour volume is 761 vehicles; the intersection is currently unsignalized.

9) Revere Street, Crest Avenue and Highland Avenue - PEER Consulants traffic data collected on 9 July 1987 show that the peak hour at this location occurs between 4:45 and 5:45 PM. The largest peak-hour volumes occur on the southbound Revere Street aprroach. The total peak-hour volume is 1,592 vehicles; the intersection is currently controlled by a blinking yellow and red flasher with no provision for phased signaling.

10) Bennington Street and Saratoga Avenue - HMM Associates traffic data collected on 1 October 1985 show that the peak hour at this location occurs between 5:00 and 6:00 PM. The largest peak-hour volumes occur on the northbound Bennington Street and westbound Saratoga Street approaches. The total peak-hour volume is 2,250 vehicles; the signal cycle time is 111 seconds.

The intersections have been analyzed for existing conditions. The existing condition analysis establishes a baseline for measuring whether additional traffic volumes moving through an intersection will affect current intersection performance.

Seven of the intersections that could be affected by additional Deer Island traffic movements along the truck route are currently unsignalized. Table 4 presents the existing condition unsignalized intersection service level analysis results. The table shows that traffic on major streets is generally unaffected by vehicles executing left turns. The exception is the westbound approach at the Main, Revere and Winthrop Streets intersection. This approach is at service level C. Service levels on minor streets range from A to F. The unsignalized intersections have been further analyzed under phased signal control to ascertain whether service levels on the minor streets would improve without severely impacting levels on major streets.

Table 4

Unsignalized Intersection Analysis Results

Intersection	Major Street						Minor Street					
	Drctn	Rsrv Cpcty	Srvc Lvl	Drctn	Rsrv Cpcty	Srvc Lvl	Drctn	Rsrv Cpcty	Srvc Lvl	Drctn	Rsrv Cpcty	Srvc Lvl
*Washington Avenue/ Shirley Street	EB	960	A				NB	277	C	SB	595	A
Washington Avenue/ Veterans Road	WB	798	A				SB	246	C			
Veterans Road/ Shirley Street	NB	870	A	SB	961	A	EB	285	C	WB	518	A
Revere Street/ Shirley Street	WB	597	A				NB	13	E			
Main, Revere/ Winthrop, Main	EB	904	A	WB	313	B	NB	56	E	NB	242	C
Winthrop, Shore/ Veterans	SB	784	A				EB LT	356	B	EB RT	810	A
Revere, Crest/ Revere, Highland	SB	766	A	NB	933	A	EB LT EB RT	-112 297	F C	WB	23	E

*Major Street/Minor Street

All ten intersections have been analyzed under phased signal control. All but five are already equipped with phased signal capability. The Washington Avenue and Shirley Street intersection, the Washington Avenue and Veterans Road intersection, the Veterans Road and Shirley Street intersection, the Winthrop, Shore Drive and Veterans Road intersection and the Revere Street, Crest Avenue and Highland Street intersection require additional equipment installation. These five intersections have been analyzed using an applicable cycle length with green time appropriately apportioned on all approaches. The remaining five intersections have been analyzed using the phasing contained on the signal permit.

Table 5 summarizes the existing condition signalized intersection service level analysis results. The majority of the streets operate at overall service levels of B. The Main, Revere and Winthrop Streets intersection shows an overall level of E because of the Main Street eastbound approach. Parking is currently allowed along this approach. Reanalyzing the intersection with 3 parking spaces removed from the eastbound Main Street approach yields service level C for the intersection as a whole. The average delay per vehicle under this condition becomes 23.3 seconds.

Minor street service levels on intersections currently operating as unsignalized would be improved by the introduction of phased control in all cases, except for the Winthrop Shore Drive and Veterans Road intersection which shows an overall service level of B. Installing phased control at this intersection would decrease the likelihood of accidents caused by unrestricted conflicting movements through the intersection. Vehicle delays could be further mitigated by installing activated signals that would only extend available green time on minor street approaches when traffic volumes warrant an increase. Major street service levels decreased to B except for the Revere, Crest and Highland intersection which decreases to C. However, the impact of phased control on the major street approaches is minor when compared to the improvement of service levels on the minor street approaches.

TRAFFIC IMPACTS MITIGATION

Intersection analysis shows that overall service levels in Winthrop range between B and C when at least basic signal phasing is used for all intersections. Negative traffic impacts likely to occur from additional traffic resulting from Deer Island wastewater treatment plant construction vehicle movements can be mitigated through addition of signalization to unsignalized intersections, changes in signal phasing, disallowance of road-side parking, and controlled scheduling of truck and worker movements.

Table 5

Existing Condition Signalized Intersection Analysis Results

Intersection	Adjusted Peak Hour Volume (vhcls)	Capacity (vhcls)	V/C	Crtcl V/C	Cycle Length (secs)	Overall Srvc Lvl	Avg Delay Per Vhcl (secs)
*Washington/ Shirley	941	2118	.44	.57	80	B	13.2
*Washington/ Veterans	944	2596	.36	.44	80	B	12.2
*Veterans/ Shirley	751	2232	.34	.48	80	B	11.6
*Revere/ Shirley	1594	3419	.47	.67	68	B	12.9
*Main, Revere/ Winthrop, Main	1648	2078	.79	.83	74	E	49.3
Main/Herman	1145	2215	.52	.61	78	B	5.1
Main/Pleasant	2147	3579	.60	.73	78	B	13.5
Bennington/ Saratoga	2461	4576	.54	.63	111	C	23.5
*Winthrop Shore/ Veterans	807	1759	.46	.46	80	B	9.4
*Revere, Crest/ Highland	2156	3288	.66	.84	90	C	17.2

*Currently operating as unsignalized.

The analysis also shows that installation of a traffic signal at all unsignalized intersections would maintain service levels on all approaches at acceptable levels. Phased control on all intersections would also help ensure safe movement of trucks to and from Deer Island. Intersections that are currently operating under flashing control can easily be reset to phased control. Five intersections require installation of phased control.

Finally, scheduling of truck and worker movements so that Deer Island traffic is not added to the morning and afternoon peak hour will also mitigate any impact to the intersections.

WORKER TRANSPORT

Worker transport options have been developed that will also minimize automobile traffic to and from the Deer Island construction site. One option is to use the Massachusetts Bay Transportation Authority (MBTA) Blue Line, with bus service connections to and from the site at Deer Island. Workers would have the option of using the Blue Line to reach the bus service connections, or driving to the stations and parking their vehicles. All of the parking lots along the Blue Line require a daily parking fee of one dollar. However, these lots generally fill before 8:00 AM, and remain filled until approximately 6:00 PM.

Another option is to establish satellite parking locations that also provide access from the MBTA Blue Line so that workers would still have the option of driving or commuting by convenient public transportation. These options are further described in a companion report entitled Construction Workers Satellite Parking Assessments.

MASSACHUSETTS WATER RESOURCES AUTHORITY

Treatment Facilities Transportation Impacts

March 1988

PEER Consultants, PC
Philadelphia, PA

MASSACHUSETTS WATER RESOURCES AUTHORITY

Treatment Facilities Transportation Impacts

TABLE OF CONTENTS

MASSACHUSETTS WATER RESOURCES AUTHORITY

Treatment Facilities Transportation Impacts

Potential local traffic impacts associated with construction of facilities for treatment of wastewater generated in the metropolitan Boston area are discussed in the pages that follow.

INTRODUCTION

This report addresses transportation impacts associated with construction of preliminary, primary, secondary, disinfection and support facilities for a new 500 million gallon per day (mgd) plant that will be built to provide treatment of wastewater for the Boston metropolitan area. The new plant will be located on Deer Island. Companion reports address traffic impacts that will result from construction of the following related improvements:

1) Early site preparation on Deer Island.

2) Effluent outfall conduit from Deer Island.

3) Influent inter-island conduit between Deer Island and Nut Island.

The recommended plan defined for the treatment facilities on Deer Island contains the following components:

1) Preliminary Treatment

   a) New screening facilities and a pump station at the existing Winthrop headworks terminal.

b) New grit removal facilities on Deer Island.

c) New screening and grit removal facilities on Nut Island.

2) Primary Treatment

a) A new preliminary treatment system.

b) A new primary sedimentation system containing 4 batteries of stacked rectangular clarifiers. Each battery has 48 tanks.

3) Secondary Treatment

a) A new oxygen activated sludge reactor and associated cryogenic oxygen generation system.

b) A new secondary sedimentation system containing 4 batteries of stacked rectangular clarifiers. Each battery has 72 tanks.

4) Disinfection

a) A new chlorination system containing 4 disinfection tanks and 3 sodium hypochlorite storage tanks.

Treatment support facilities will also be constructed on Deer Island. These facilities include:

a) Power plant.
b) Main pump station.

c) Existing potable water system improvements.

d) Plant water system.

e) Laboratory facility.

f) Administration building.

g) Employee building.

h) Maintenance shop and storage facility.

i) Spare parts warehouse.

The existing primary treatment facility on Nut Island will be removed and replaced with a new headworks that will discharge influent to the inter-island conveyance tunnel via a vertical access shaft. The tunnel will then carry the influent to the facilities located on Deer Island for treatment.

Transportation requirements to Deer Island and Nut Island for construction of the facilities described above include initial transport of construction equipment, periodic transport of materials, and daily transport of workers during all phases of construction. All of this represents traffic between the mainland and the island plant sites that must be added to existing movements.

Both islands are linked to the mainland. Deer Island is connected by a causeway reached by passing over local roads through the town of Winthrop. Nut Island, located at the tip of a land mass that is part of the mainland, is reached by passing over local roads through the town of Quincy. Nut Island traffic may also travel over local roads in Braintree and Weymouth to reach Quincy from the arterial highway network.

All of the construction material and equipment traveling to and from Deer Island will be barged over water to new pier facilities. In accordance with the Massachusetts Water Resources Authority mitigation commitments to the town of Winthrop, half of the workers will be bused to Deer Island from satellite facilities through Winthrop and across the causeway that links Deer Island to the mainland, and half will be ferried aross Boston Harbor to Deer Island.

The sections that follow describe the facility construction sequence and estimated daily worker and truck trip volumes that could result from the construction. The discussion begins, however, with a summary of findings.

FINDINGS

Treatment facilities construction will occur between 1991 and 1999. The estimated daily construction worker requirements range from 155 to 875. Peak worker needs occur in 1992 and 1993 during primary treatment facilities construction, and in 1996 and 1997 during secondary treatment and aeration facilities construction. Worker requirements are at least 50% less than the peak in 1991, 1994, 1998 and 1999; and about 30% less in 1995.

At least one-half of the construction workers will be ferried over water from existing ferry facilities to Deer and Nut Islands; the other half will be bused overland to Deer Island through Winthrop, from satellite parking facilities on the mainland. Essentially all of the equipment and material movement to the Islands will be over water by barge using the newly constructed on-shore piers or other remote docking facilities. Regardless, overland truck movements through Winthrop have been limited to eight 2-axle trucks per day for construction equipment and material deliveries. Communities potentially affected by construction traffic movements to the Deer and Nut Islands have been addressed in previous reports to the Massachusetts Water Transportation Authority (MWRA).

Estimated daily truck volumes including excavated material removal and bulk deliveries range from 20 to 170. The highest volumes are generated from 1992 through 1993 and from 1996 through 1997 and are a direct result of facility construction schedule overlaps. Daily truck volumes are at least 25% less than the peak in 1995, at least 40% less in 1994 and 1998; and more than 50% less in 1991 and 1999. The above truck volumes decrease to a range of 20 to 155 trucks a day when excavated material removal quantities are reduced by a percentage that recognizes a portion of the material will be used on Deer Island.

It is also likely that all of the bulk material shipments will originate at docking facilities close to supply sources for transport over water to Deer Island and Nut Island, greatly reducing possible truck trip volumes to the newly constructed on-shore pier facilities. Daily truck volumes could be decreased by as much as 86 percent if these bulk shipments are handled at remote mainland docking facilities. Estimated daily truck volumes would then range from 5 to 55.

FACILITY CONSTRUCTION SEQUENCE

Construction of the various facilities has been divided into nine categories. These categories are:

1) Deer Island site preparation 2.
2) Primary treatment facilities.
3) Secondary treatment facilities.
4) Aeration facilities.
5) Administration building.
6) Maintenance facility.
7) Nut Island headworks.
8) Winthrop terminal & north pump station.
9) Deer Island site preparation 3.

The majority of the sitework and earthwork on Deer Island will be accomplished during site preparation 2 and 3. Depending in the length of the selected effluent outfall tunnel, between 6.01 and 6.44 million cubic yards of material will be excavated; a total of 1.64 million cubic yards will require removal and disposal off-island. The rest of the material will be used on-island for establishing construction grades, for creation of land-form barriers and for back-filling around structures. Most of the back-filling, final grading, landscaping and roadway and walkway construction will occur during site preparation 3.

Figure 1 shows the construction schedule as of August 1987. Site preparation 2 begins in January 1992 and continues to December 1995. The primary treatment facilities, secondary treatment facilities and aeration facilities will each be constructed in two trains. Train A construction for the primary treatment facilities begins in January 1991 and ends in mid-1993; train B construction is from January 1992 to mid-1994.

The secondary treatment facilities train A construction begins in January 1995 and ends in December 1997; train B construction is from January 1996 to mid-1999. Construction for aeration facilities train A is from January 1995 to mid-1997; train B construction begins in January 1996 and ends in December 1998.

The administration building will be constructed from January 1992 to mid-1993. The maintenance building construction will begin in January 1996 and end in December 1997. Construction of the Nut Island headworks is from mid-1992 to December 1995; the Winthrop terminal and north pump station construction is from January 1992 to mid-1993. Finally, site preparation 3 construction work is from January 1996 to December 1999.

It is expected that the on-island and on-shore pier facilities construction will be complete and in operation for use in delivering construction equipment and material over water to the island. Construction material and equipment water transport to and from Deer and Nut Islands will be by barge using the newly constructed piers; however, the equipment and material must first be transported overland to the mainland pier facilities. It is possible that the material will be trucked to the on-shore pier facilities if rail transport is not available. Communities surrounding the piers thus could be affected by construction truck traffic.

Material transport overland to the newly constructed on-shore pier facilities will be mitigated by waterborne delivery of bulk shipment materials to the island from remote mainland locations. The material will be loaded onto barges at docking facilities that are located close to supply sources.

FACILITY	1991	1992	1993	1994	1995	1996	1997	1998	1999
Site Preparation 2		XXXX	XXXX	XXXX	XXXX				
Primary Treatment									
Train A	XXXX	XXXX	XX						
Train B		XXXX	XXXX	XX					
Secondary Treatment									
Train A					XXXX	XXXX	XXXX		
Train B						XXXX	XXXX	XXXX	XXXX
Aeration Facilities									
Train A					XXXX	XXXX	XXX		
Train B						XXXX	XXXX	XXXX	
Administration Building		XXXX	XX						
Maintenance Facility						XXXX	XXXX		
Winthrop Terminal		XXXX	XX						
Site Preparation 3						XXXX	XXXX	XXXX	XXXX
Nut Island		XXX	XXXX	XXXX	XX				
Inter-Island Conduit*	XX	XXXX	XXXX	XX					
Effluent Outfall Conduit*	XX	XXXX	XXXX	XXXX	XX				

* Not part of treatment facilities construction.

Worker transport will be over water using ferries from existing on-shore facilities and over land using buses that will travel between Deer Island and mainland satellite parking facilities. Worker ferry transport has been addressed in reports identified in later paragraphs; busing workers to and from satellite parking facilities is addressed in a companion report entitled Construction Workers Satellite Parking Assessments.

ESTIMATED WORKER AND TRUCK VOLUMES

A method has been developed for use in quantifying potential worker and truck trip volumes in the absence of detailed worker-hour, material quantity and equipment requirement information. Truck movements and work force needs have been estimated using available data on total construction costs for the proposed facilities. Refinements to the truck and worker volume estimates may be neccesary when more specific information becomes available. The criteria used in developing the estimates are described below.

The required construction for the various facilities has been divided into eleven general components. Two of these components, earthwork and sitework, comprise almost all of the site preparation 2 and site preparation 3 construction. All other facility construction also includes some or all of the nine components listed below. Component construction occurs at specific time periods during the overall facility construction duration. The components and associated time periods are listed below.

1)	Concrete	First 2/3.
2)	Mechanical Equipment	Last 1/2.
3)	Masonry	Middle 1/3.
4)	Steel and metals	Last 1/2.
5)	Electrical	Last 1/2.
6)	Instrumentation	Last 1/3.
7)	HVAC	Last 1/2.
8)	Plumbing	Last 1/2.
9)	Finish work	Last 1/4.

Using the capital costs developed for each facility, percentages of total construction costs have been estimated for the components listed above. These cost percentages vary depending on the facility type under construction. The overall cost for each component was then be apportioned into equipment, labor and material cost percentages, again using the capital costs developed for each facility. These apportioned cost percentages also vary among the components. Quantity was assigned to each component, and a cost per unit estimated.

Dividing the cost per unit into the total component cost provided an estimate of overall component material quantity. An assessment of the quantity a truck can carry was then made so that total hauls per component could be estimated. Dividing the total hauls by component construction duration provided an estimate of the component daily truck trips. Summing the component truck trips and subtracting out separate trip timings provided an overall estimate of daily facility construction truck trips.

A daily worker estimate has been developed in the same manner. The component cost specific to labor was extracted from the estimated facility component labor cost percentage, and the cost associated with fringe benefits was subtracted from the overall labor cost to establish the no-fringe payroll cost. The no-fringe payroll cost was then divided by the component construction duration to establish the per-day no fringe payroll cost.

A daily worker wage for each component was assigned. The wage was then divided into the per-day payroll cost so that a component construction daily worker requirement could be estimated. The facility component worker requirements were summed and separate construction timings were subtracted out.

Table 1 summarizes the estimated daily and worker truck volumes for each construction category. The highest worker requirements are for site preparation 2, primary treatment, secondary treatment and aeration facilities construction; the highest peak truck trip volumes are generated by primary and secondary treatment activities.

Table 1

Estimated Treatment Plant Daily Worker and Truck Volumes

FACILITY	WORKERS AVERAGE	WORKERS PEAK	TRUCKS TO PIERS AVERAGE	TRUCKS TO PIERS PEAK	TRUCKS TO PIERS LESS % EXCVTD MTRL AVERAGE	TRUCKS TO PIERS LESS % EXCVTD MTRL PEAK	TRUCKS TO PIERS PERCENT DECREASE AVERAGE	TRUCKS TO PIERS PERCENT DECREASE PEAK	TRUCKS TO PIERS LESS BULK SHIPMENT AVERAGE	TRUCKS TO PIERS LESS BULK SHIPMENT PEAK	TRUCKS TO PIERS PRCNT FRTHR DCRS AVERAGE	TRUCKS TO PIERS PRCNT FRTHR DCRS PEAK
Site Preparation 2	100	130	35	35	20	20	43%	43%	20	20	0%	0%
Primary Treatment												
Train A	155	205	20	35	20	35	0%	0%	5	5	75%	86%
Train B	155	205	20	35	20	35	0%	0%	5	5	75%	86%
Secondary Treatment												
Train A	220	290	25	50	25	50	0%	0%	5	5	80%	90%
Train B	220	290	25	50	25	50	0%	0%	5	5	80%	90%
Aeration Facilities												
Train A	75	95	10	20	10	15	0%	25%	5	10	50%	33%
Train B	75	95	10	20	10	15	0%	25%	5	10	50%	33%
Administration Building	20	25	5	5	5	5	0%	0%	5	5	0%	0%
Maintenance Facility	55	75	5	10	5	10	0%	0%	5	5	0%	50%
Nut Island Headworks	55	70	10	20	5	10	50%	50%	5	10	0%	0%
Winthrop Terminal	65	85	10	20	10	10	0%	50%	5	10	50%	0%
Site Preparation 3	25	30	10	20	10	15	0%	25%	10	15	0%	0%

YEAR	WORKERS AVERAGE	WORKERS PEAK	TRUCKS TO PIERS AVERAGE	TRUCKS TO PIERS PEAK	TRUCKS TO PIERS LESS % EXCVTD MTRL AVERAGE	TRUCKS TO PIERS LESS % EXCVTD MTRL PEAK	TRUCKS TO PIERS PERCENT DECREASE AVERAGE	TRUCKS TO PIERS PERCENT DECREASE PEAK	TRUCKS TO PIERS LESS BULK SHIPMENT AVERAGE	TRUCKS TO PIERS LESS BULK SHIPMENT PEAK	TRUCKS TO PIERS PRCNT FRTHR DCRS AVERAGE	TRUCKS TO PIERS PRCNT FRTHR DCRS PEAK
1991	155	205	20	35	20	35	0%	0%	5	5	75%	86%
1992-1993	550	720	100	150	80	115	20%	23%	45	55	44%	52%
1994	310	405	65	90	45	65	31%	28%	30	35	33%	46%
1995*	450	585	80	125	60	95	25%	24%	35	39	42%	59%
1996*	670	875	85	170	85	155	0%	9%	35	64	59%	59%
1997*	670	875	85	170	85	155	0%	9%	35	60	59%	61%
1998*	320	415	45	90	45	80	0%	11%	20	39	56%	51%
1999	245	320	35	70	35	65	0%	7%	15	20	57%	69%

* Truck volumes have been adjusted to account for specific excavated material removal requirements.

It has been assumed conservatively for purposes of these estimates that all necessary material movements are by truck. However, it is expected that a portion of the excavated material will be used on Deer Island; this prospect is accounted for in the table. Truck trip volumes would also be reduced by bulk material deliveries by barges originating from mainland facilities close to supply sources. As shown in Table 1, truck trip volumes could be reduced by as much as 86 percent when bulk materials are delivered by barge from remote locations.

Construction schedule overlaps occur among the various facility construction categories. The primary treatment facility construction overlaps with the administration building, Winthrop terminal and Nut Island headworks work and site preparation 2 work. The secondary facilities, aeration facilities, maintenance facilities and site preparation 2 and 3 activities occur during the same time period. Table 1 also shows the range of daily workers and truck trips that will occur each year during construction of the facilities.

The largest daily worker and truck trip volumes occur from 1992 through 1993 and 1995 through 1997 and are a direct result of construction schedule overlaps among site preparation 2 and primary treatment facilities work and secondary treatment facilities and aeration facilities work.

SIMULTANEOUS CONSTRUCTION PROJECTS

The above section describes only the estimated daily truck and worker volumes that could be generated from treatment facility construction on Deer Island and Nut Island. Other construction will occur on Deer Island during the same period. Site preparation 2, primary treatment facilities, administration building, Nut Island headworks and Winthrop Terminal construction coincide with influent inter-island conduit and effluent outfall conduit work. The secondary treatment and aeration facilities work could overlap with effluent outfall construction depending on the outfall option selected.

Construction of the inter-island influent tunnel will occur between January 1991 and December 1994. Effluent outfall construction will begin no later than March 1991 and will end in December 1994 for the 8.5-mile tunnel option or in December 1995 for the 10.2-mile tunnel option. Cumulative truck and worker volumes that could result because of construction schedule overlaps among treatment facilities, influent conduit and effluent conduit construction have not been examined. However, they are summarized in Appendix K of the Secondary Facilities Plan Volume III, Treatment Plant.

SOUTH SHORE TRAFFIC IMPACTS

Construction traffic impacts to Quincy and surrounding communities have been addressed by others in studies prepared for the Massachusetts Water Resources Authority (MWRA) during the on-shore water transportation facilities planning project. The potential traffic impacts in these communities associated with the treatment facility construction described above have not been examined here and are not discussed in this report.

WINTHROP TRAFFIC IMPACTS

Winthrop traffic impacts resulting from construction automobile and truck traffic have been examined in other reports to MWRA and are not discussed in this report. However, impacts resulting from treatment facilities construction will be minimal as material and equipment will be barged over water to Deer and Nut Island pier facilities; workers will either be ferried over water or bused to Deer Island through Winthrop from satellite parking facilities.

MASSACHUSETTS WATER RESOURCES AUTHORITY

Deer Island Secondary Treatment Plant Construction

Construction Workers Satellite Parking Assessments

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PEER Consultants, PC

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MASSACHUSETTS WATER RESOURCES AUTHORITY

Deer Island Secondary Treatment Plant Construction

Construction Workers Satellite Parking Assessments

TABLE OF CONTENTS

MASSACHUSETTS WATER RESOURCES AUTHORITY

Deer Island Secondary Treatment Plant Construction

Construction Workers Satellite Parking Assessments

INTRODUCTION

This report summarizes satellite parking transport feasibility assessments for movement of construction workers between Deer Island and satellite parking facilities.

Deer Island is connected to the mainland by a causeway. The causeway is accessed by passing over local roads through the town of Winthrop. The Island will also be accessible by water once the new on-island pier facilities are constructed and in operation. Construction worker transport over water by ferry has been addressed in previous reports to the Massachusetts Water Resources Authority. Analysis of traffic issues and potential impacts to communities resulting from movements of workers to and from Deer Island over water are not examined here.

Since not all workers may conveniently have access to the ferry loading areas, some of the workers required at Deer Island may still need access over the land route through Winthrop. The Authority is required to provide an alternate capability that will be complementary to the use of ferry operations for many of the workers, and not a substitute for the waterborne alternative.

For purposes of analysis and impact assessment, it has been assumed here that as much as half of the total work force required at Deer Island may seek access by land. For the most part, these workers will be coming to the worksite from residential locations in the eastern, northern and northwestern parts of the metropolitan Boston region.

Since earlier investigations have indicated that an arrangement allowing unrestricted access to Deer Island by automobile would give rise to unacceptable traffic management problems in Winthrop, the workers seeking access by land will have to do so by traveling to satellite parking areas by automobile or other means, for transfer and delivery to the worksite by bus.

Several options are available to employ this concept. The one that now appears most attractive would be to extend the operating authority of the bus company currently serving Winthrop, to allow scheduled vehicles to service parking facilities that would be developed at locations along or near the MBTA Blue Line through East Boston and nearby communities. Opportunities for developing appropriate parking and transfer facilities at locations along this corridor are discussed in the report that follows.

RECOMMENDATIONS

Parking for approximately one-half of Deer Island total work force could be accomodated by linking three satellite parking facilities to the Deer Island work site by bus. The three facilities are located along or near the MBTA Blue Line, at the Orient Heights Blue Line Station, the Suffolk Downs Race Track, and the Metropolitan District Commission (MDC) lot north of Wonderland.

Satellite parking at these locations could provide a combined capacity of approximately 1,150 parking spaces for worker vehicles, in close proximity to each other as well as to the Deer Island work site. All three sites are accessible by automobile and by public transit. Placing bus stops at these three sites gives workers flexibility to choose where they will park and how they will get to the satellite facilities.

The Orient Heights MBTA Blue Line station located in East Boston has parking facilities northeast of the intersection of Bennington and Saratoga Streets. These facilities currently serve Blue Line commuters and are filled to capacity each day. The lot can be improved to provide an additional 50

parking spaces. Most workers using the Blue Line to commute to satellite facilities would disembark at this location. Providing bus service to Deer Island at Orient Heights will serve mainly workers able to use public transport for movement to and from the construction work site.

The Suffolk Downs Race Track is located south of Winthrop Avenue in Revere and can be reached from the Suffolk Downs and Beechmont MBTA Blue line Stations. The race track has a capacity of approximately 3,200 parking spaces; at least one-fourth could be available for Deer Island worker parking without reducing the space currently used by race track patrons.

The Metropolitan District Commission (MDC) parking lot is located on Ocean Avenue south of Revere Street and is just north of the eastern portion of the Wonderland MBTA parking facility that currently serves Blue Line commuters. The MDC lot can be marked to hold approximately 600 parking spaces; one-half could be available for Deer Island worker vehicles without reducing the space currently used by other commuters.

It is expected that most workers will travel to the satellite areas by automobile; only a small percentage will use public transit for commuting. Intersections in the vicinity of the three sites that could be affected by the additional construction worker automobile traffic have been identified. These intersections have been analyzed to assess existing levels of service and to ascertain whether the increased construction traffic would reduce these service levels. The analysis is described in an attached appendix.

Bus service to the three sites would occur along two routes with no more than one bus per stop at any one time. Currently, the Orient Heights Station is served by Rapid Transit Service, Inc. of Winthrop. Authority for this existing bus service which runs from the Orient Heights Station through Winthrop could be extended to service Deer Island.

One route (Route 1) would provide service between the Island and Orient Heights Station and the other route (Route 2) would provide service between the Island, Suffolk Downs Race Track and the MDC Lot. Total round trip

distances are 9 miles and 10.5 miles respectively for Route 1 and Route 2. Approximately three Route 1 buses and five Route 2 buses, traveling at 15 mph average speeds and at 15-minute and 10-minute scheduled service intervals, are required to transport workers during peak shift change periods. The average one-way travel time between Deer Island and a satellite facility will not exceed 30 minutes.

Costs for developing and operating the satellite parking areas are relatively modest since planned use would not depart from current use. At most, paving and striping of lots, and establishment of bus stop areas are needed. Lot attendants are required to assure that un-authorized vehicles are not parked in spaces reserved for workers, and to assure that parked vehicles are not vandalized. The estimated development cost for the three areas is $1.3 million, and the estimated annual security cost is $285,000.

The Orient Heights Station and MDC lot management charge a daily fee of $1.00 for parking and provide security surveillance of lots. Parking at the Race Track is free and minimal security is provided. It is expected that arrangements for use of the three lots could be worked out with current management, since facility improvements would be initiated by the Authority and the planned site use is an extension of current and projected use.

Bus service costs include vehicle operation and maintenance. A cost per-worker-trip would be established and the bus service company would receive recompense based on worker service use. Costs for transporting workers by bus daily between Deer Island and the satellite facilities would be recouped through the aggregate worker-trip fares generated.

Permanent satellite parking facilites would be required to accomodate approximately 480 plant administrative, operations and maintenance workers each day. The Suffolk Downs Race Track and MDC Lot both have space available to support these parking requirements. Either one or both lots could be used as a parking facility provided suitable arrangements for permanent use of the sites could be worked out with current management. Lot operation would be

similar to the temporary construction worker parking plan described here; the construction workers bus service plan could also be revised to provide scheduled service for ongoing Plant personnel.

ASSESSMENT METHOD

To examine options available to the Authority for development and use of satellite parking facilities that would support daily transfer of a significant portion of the construction work force needed at the Deer Island worksite, a method of assessment has been applied that includes:

1) Preliminary identification of potential parking sites having reasonable proximity to Deer Island that could potentially be used to satisfy Authority purposes during the intended construction period.

2) Elaboration of a specific set of screening criteria for use in evaluating the candidate parking sites.

3) Application of these criteria to identify a specific set of locations that would most likely fit the Authority's purposes, with minimal adverse effect on other aspects of daily commutation in the Boston metropolitan region.

4) Detailed assessment of requirements at the better candidate locations for satellite parking, considering possible arrangements for use of existing facilities, requirements for physical improvement of facilities, public transport access, existing traffic conditions, Deer Island construction traffic flows and potential transportation impacts.

5) Definition of a bus service operating plan capable of handling the worker movements between satellite parking facilities and Deer Island, without unacceptable impact on street traffic in Winthrop or public transport service along the MBTA Blue Line.

6) Analysis of traffic flows and performance at intersections that may be critically affected by daily movements to and from the satellite parking facilities, to assess potential impacts and identify desirable mitigation actions.

7) Estimation of costs that would be involved in the development of appropriate facilities, their operation to accommodate Deer Island construction workers and the operation of public transport service to provide connection between the satellite parking facilities and the worksite at Deer Island.

8) Comparative evaluation of relative costs and advantage for the Authority, and identification of potential cost-sharing arrangements.

A first requirement, and a key feature in this methodology, concerns the explicit definition of criteria used for the initial screening evaluations. These are discussed in the paragraphs that follow.

SCREENING CRITERIA

Twelve general criteria have been used for the purpose of screening candidate sites that might be acceptable for use as locations for satellite parking where Deer Island workers would leave automobiles during work shifts

for transfer to and from the worksite on Deer Island by bus. The 12 criteria include:

1) Ease of general access by automobile and public transport service.

2) Proximity to the Deer Island worksite.

3) Presence and availability of existing parking facilities.

4) Ease of prospective arrangements for use by Deer Island construction workers.

5) Ease of parking facility improvements, if needed.

6) Ease of providing security for parked vehicles.

7) Degree of compatibility with nearby land uses, both existing and planned.

8) Degree of public controversy that may attach to use of space by Deer Island construction workers.

9) Ease of access to and from Deer Island by transfer bus.

10) Relative prospective efficiency of transfer bus service operations.

11) Severity of prospective transportation impacts and ease of mitigation.

12) Approximate costs of the development and use of parking facilities and related transfer bus services.

Each of these criteria for evaluation and assessment is described briefly in the paragraphs that follow. The order of exposition is not intended to suggest relative priority. The criteria have been used to address the issues related to each prospective site. Each prospective site has been considered on its own merits, for the purpose of identifying a reasonable set of alternatives for providing a level of service that would allow as many as half of the construction workers needed at Deer Island to reach the worksite daily through the satellite parking facilities and the transfer bus services.

A first requirement is that a satellite parking location be accessible by automobile. This means that the site must be within relatively easy reach of major highway facilities serving the metropolitan Boston region, and that the local arterial and street connections provide access for entry to and egress from the proposed parking spaces without complicating existing conditions of traffic flow on local streets. Because there is advantage in spreading the prospective traffic load, this criterion concerning ease of access also suggests that some desirability may lie in providing more than one location where satellite parking and transfer bus services would be provided.

In addition to the potential problems for the local street network, the ease of access criterion also extends to the degree to which a selected site for satellite parking may also be accessible for workers who would commute to and from the Deer Island site using the MBTA public transport services. There may only be a few such workers, but the presence of the MBTA Blue Line in the corridor providing access to Deer Island means that the parking facilities should also be developed in relatively close proximity to the MBTA stations if possible. Workers using this means of transport to the construction site would be moving generally in a direction opposite to normal peak flows on the rapid transit system, and may be able to travel to and from the construction worksite on Deer Island at nearly minimal cost, for themselves and others.

A second criterion of some importance concerns proximity to the Deer Island construction site itself. The requirement here is that time needed for the transfer trips between the parking lots and the worksite itself be minimized. This is desirable to avoid delay and lost time for workers as well

as to restrain the cost associated with the transfer movement. Proximity to Deer Island can be considered in several ways. Of interest is the matter of distance between the satellite parking facility and Deer Island, as well as available street access and the degree of circuity that may be required in bus service operations. Additionally, obtainable speeds in bus service are relevant to minimize the time needed for transfer movements. The questions of proximity to Deer Island have been examined in terms of the time that would be required for movement of construction workers to and from the site.

Where parking facilities may already exist on some candidate locations, this presents a distinct advantage. Of interest in such situations is a series of questions regarding the number of parking spaces present, the timing and intensity of their use, the degree to which existing spaces may be available for use by construction workers, and the degree to which the purposes that construction worker use would serve may conflict with the timing of other, established demand for use of the space. Wherever complementary use involving the construction workers might be achieved, the possibilities for purposes of the Deer Island construction project are improved.

In addition to the matter of whether or not existing facilities may be present and available for use, more general considerations regarding ownership and control of existing parking facilities or available plots of land must be considered. These issues have been examined on a general basis without approaching current owners or initiating discussions concerning specific arrangements that might be made for use of existing facilities or land to support satellite parking for the Deer Island construction project. Nonetheless, the matter of general availability and probable ease of securing such arrangements has been considered along with the other criteria discussed in these paragraphs.

Related to the questions of access to land and facilities for such use is the matter of possible requirements or options for improvement of land, or of existing parking facilities, to support use by the Deer Island construction workers. Options that may be available for expansion of existing facilities,

or for their restoration and improvement have been considered as potentially desirable steps, along with the relative degree of difficulty that may be involved in accomplishing them.

In similar fashion, the ease or difficulty that may reside in providing sufficient security for workers and the automobiles that they would leave at the satellite parking locations has been considered. Where arrangements may already exist for basic security of parked vehicles, these have been identified and noted as suggesting a relatively easy solution to the security requirement that must be satisfied in order to persuade Deer Island workers to use the satellite parking and transfer bus arrangements. Where existing arrangements may not already be present, the need to provide them has been considered; in either case, the costs associated with providing sufficient security have been recognized in the quantitative assessments made.

Compatibility of the intended parking and transfer use to land use in the surrounding area has also been considered as a criterion for evaluating satellite parking candidate locations. The use to support Deer Island construction could extend through a period of between five and ten years. Compatibility with nearby land use has been considered therefore both in terms of present or committed land-use development and the planned intentions of local municipalities and others.

Related to the matter of land use is the degree of public controversy that might surround commitments that would be needed to allow satellite parking and bus transfer services to be established to support the Deer Island construction. The possibility that an action to secure such arrangements in any location might engender an unacceptable level of public controversy has been weighed in the evaluations performed.

Since the satellite parking concept is dependent on transfer of workers to and from the construction site itself by bus, the ease of access for bus movements entering and leaving the satellite parking locations has also been considered. In this, since the level of service needed to carry as many as

half of the expected construction workers would not require bus service movements at intervals shorter than two minutes, problems of access for entry to and egress from the satellite parking locations are not likely to be great. In general, no more than one bus vehicle would need to be present at any satellite parking site at any given time; and sufficient time would be available to load or unload and depart from the site well before a next bus would seek entry to achieve the same purposes.

In addition, possibilities for significant advantage in the matter of bus service operating efficiencies have been considered as a separate criteria. In the interest of spreading load and using multiple sites for satellite parking, the options that may exist for using a linked bus service pattern that would have buses moving over a prescribed route and stopping at more than one parking facility have been considered, as well as the direct service arrangements that may be more appropriate at times of particularly large transfer loads.

Given all of this, a criterion of significant importance relates to the severity of residual impact that the traffic movements and bus services supporting the Deer Island construction workers may have on local street traffic and other public transport operations. In assessing residual transportation impact, both existing conditions and those expected to prevail with the Deer Island services in place must be considered, and the specific locations, times and manner of adverse impact must be considered. Along with this, the relative ease that may reside in steps that would be taken to mitigate potential impact has also been considered as a general criterion.

Finally, relative approximate costs associated with all of the actions that would be taken have been considered. These extend to the requirements for securing land or facilities for use, building or improving parking facilities, operating the parking facilities (including necessary security arrangements) and the operation of the transfer bus services that would carry workers to and from the Deer Island worksite.

The use of these criteria in evaluation of candidate locations for satellite parking is described more fully in a later section of this report, where the available information on each site has also been arrayed to support the evaluations made and the conclusions drawn.

LOCATIONS ASSESSMENT

The initial choice of possible satellite parking locations has been based on location and present use. After observance in the field, the following eight locations were selected as possible satellite parking options:

1) The Orient Heights MBTA Blue Line Station;

2) The Suffolk Downs MBTA Blue Line Station;

3) The Beachmont MBTA Blue Line Station;

4) The Suffolk Downs Race Track;

5) The Revere Beach MBTA Blue Line Station;

6) The Wonderland MBTA Blue Line Station;

7) The Metropolitan District Commission Lot next to or north of the Wonderland Station; and

8) The Northgate Shopping Center.

Table 1 presents a site selection criteria matrix. The twelve criteria described in the previous sections were each applied to the eight sites. For each site a criterion was rated as good (G), fair (F), poor (P) or not applicable (N/A). Inspection of the matrix shows that the Suffolk Downs

Table 1

Site Selection Criteria Matrix

Criteria	Orient Heights	Suffolk Downs	Beach-mont	Race Track	Revere Beach	Wonder-land	MDC Lot	North-gate
Worker Access	G	G	G	G	G	G	G	G
Proximity	G	G	G	G	G	G	G	P
Exstg Prkg	P	P	F	G	P	P	G	G
Arrangements	G	G	N/A	G	P	P	G	F
Improvements	G	P	P	G	P	G	G	G
Security	G	G	G	G	P	G	G	F
Compatibility	G	P	G	G	G	G	G	G
Controversy	G	P	G	G	P	G	G	G
Bus Access	G	G	G	G	G	G	G	F
Transprtn Impacts	G	G	P	G	G	G	G	P
Cost	G	P	N/A	G	G	G	G	G

Station, the Beachmont Station, the Wonderland Station, and the Northgate Shopping Center may be eliminated as possible sites. A summarized assessment of each of these four sites can be found in the paragraphs below.

The Suffolk Downs Station and parking facility both lie east of the Blue Line tracks, along the west side of Bennington Street. It is the eighth stop on the Blue Line route which originates at Bowdoin Station in Boston and terminates at Wonderland Station in Revere. Approximately 180 commuter vehicles are parked along each curb of Bennington Street in the vicinity of the Suffolk Downs platforms filling the majority of parking spaces throughout the day. The Suffolks Downs Station off-street parking lot has space for approximately 100 automobiles, and is also filled by commuter vehicles. Construction of additional parking space at Suffolk Downs would be expensive and controversial, since all of the nearby ground is in salt marsh fenns. Land east of Bennington Street is part of Frederick's Park, and not likely to be available for parking facility construction.

The Beachmont Station is an elevated structure carrying the Blue Line over Winthrop Avenue in Revere. It is the next stop north of the Suffolk Downs Station on the Blue Line route. Parking for this station is located on the west side of the Blue Line tracks, where an at-grade lot has been built to accomodate approximately 400 automobiles. Most of these spaces are currently occupied by commuter vehicles throughout the day. Expansion of the lot is precluded by surrounding roadways and land development. It is possible that a parking garage could be built on the lot; however, the required construction would interupt use of off-street station parking at the station.

The Revere Beach Station is located on Shirley Street west of Ocean Avenue; Ocean Avenue turns into Bennington Street 1 mile south of the Station. The station has no off-street parking facilities and there is no land readily available for parking facility development. Commuters accessing this portion of the Blue Line park their automobiles along Ocean Avenue. The curb-side parking is currently restricted between the hours of 7:00 and 9:30 a.m. to alternate sides of the street dependent on the day. This limitation

effectively restricts commutation parking to only one side of the street; the 200 parking spaces available on any given day are currently all used by commuters. It is possible that parking regulation could be revised to allow Deer Island construction workers to park in the currently restricted areas. However, there would be limited security for vehicles and it would greatly decrease parking availability for persons traveling to area beach and commercial destinations.

The Wonderland Station has a large lot containing approximately 650 parking spaces on the west side of the Blue Line tracks, just south of the Wonderland Ballroom. This lot is filled by commutation parkers through most of the day. There is also a smaller lot of 250 spaces on the east side of the Blue Line tracks at the Wonderland Station, it is also filled throughout the day. The MBTA has formulated plans to improve the Wonderland Station; these plans include a garage located on the western parking lot. It is intended that the garage be used by Blue Line commuters. The current and projected need for Blue Line commutation parking at the Wonderland Station makes it a less viable site for Deer Island satellite parking.

Finally, the Northgate shopping center has also been eliminated as a possible satellite parking area. The Center is located in the northwestern section of Revere on Squire Road just south of its junction with Route 1. Of the eight sites considered, Northgate is the farthest from Deer Island. In addition, its lack of proximity to other satellite parking areas would lower bus routing efficiency; a separate bus route would be required to service this site. The current traffic congestion along Squire Road raises questions concerning the ability of current traffic to subsume construction worker traffic without unacceptable effects.

While the sites above fall short on the twelve criteria, the Orient Heights Station, the Suffolk Downs Race Track and the MDC Lot score highly. In all cases, access is easy and proximity to Deer Island and to each other is close. This proximity will reduce operating costs, and will increase bus transport efficiency.

The three sites are all currently used as parking facilities and both the Race Track and the MDC Lot could accommodate increased parking at their present capacities. Available parking at the Orient Heights Station could be increased by approximately 50 additional spaces at a relatively low cost.

Current operations and activities at the three sites would not be greatly affected since the proposed parking facilities planned use does not differ from present use. Security would continue in the same manner with improvements and cost-sharing implemented as warranted. Compatability with nearby land uses would be lasting, and issues of public controversy would be minimized. Necessary arrangements could evolve from current management procedures at the three parking facilities.

Required improvements to the sites would be minimal with the most extensive being new paving, striping and expansion of existing security arrangements. Also, bus routing need only cover a limited distance and number of vehicles. Consequently, the cost of development and operations of the satellite parking facilities would be low.

Detailed descriptions of the Orient Heights Station, the Suffolk Downs Race Track and the MDC Lot are contained in the paragraphs below.

ORIENT HEIGHTS STATION

The Orient Heights MBTA Station (Orient Heights) is located north of the intersection of Bennington and Saratoga Streets in East Boston. It is just south of the principal maintenance shops and storage yard for the Blue Line. The parking lot lies generally north of the station platforms and south of the maintenance facilities, and is east of the Blue Line tracks. Use of the parking lot requires a daily fee of $1.00.

Orient Heights is the seventh stop when traveling east along the MBTA Blue Line. The Blue Line provides access to Boston's North Shore suburbs with connections to public transit lines serving the entire Boston metropolitan area.

Parking at Orient Heights accommodates approximately 400 vehicles. Since the facility is used primarily for commutation purposes, spaces fill in the morning before 8:00 a.m.; and remain filled for the most part until approximately 6:00 p.m.

Space not currently in use between the northern end of the existing parking lot and the southern access road into the maintenance yard could be developed to accommodate approximately 50 additional automobiles. The required work involves initial site preparation, paving and striping.

The existing bus boarding area is south of the present parking lot on the east side of the station platforms. Workers arriving at the station by automobile and parking in the newly-constructed lot would have a relatively long walk to this boarding area. However, buses could collect workers arriving via the Blue Line at the existing stop and then proceed to a new bus stop near the intersection of Saratoga Street and St. Edward Road to collect workers arriving by automobile. This new stop would provide close access to the parking facility without requiring buses to travel over narrow residential streets.

Workers traveling to Orient Heights by car would travel mainly on Bennington Street, through the intersection of Bennington Street and Saratoga Street and then east on Saratoga Street to the station parking lot. The Bennington Street and Saratoga Street intersection could be affected by construction worker traffic.

Fifty additional parking spaces at the Orient Heights Station could generate an additional 50 automobiles entering and exiting the lot during construction. Because of the relatively small amount of parking available, it is possible that one construction shift could generate all the additional traffic; this worst-case scenario has been used in analyzing the Bennington and Saratoga Streets intersection. The analysis is described in an attached appendix.

SUFFOLK DOWNS RACE TRACK

The Suffolk Downs Race Track is west of the Beachmont Station between Bennington Street and North Shore Drive. The track holds races from 1:00 to 5:00 PM daily except Tuesday and Thursday, and seats 20,000 spectators.

The Suffolk Downs Race Track has a parking capacity of approximately 3200 spaces. During non-racing days, the parking facilities are virtually unused; during race days at least one-fourth of track parking, or 800 spaces are unused and could be made available for Deer Island worker parking. Parking facility improvement requirements for this option are minimal. Repaving and restriping the lot would increase parking safety and efficiency.

The race track is accessible by foot from both the Suffolk Downs and Beachmont MBTA Blue Line Stations. The southeast portion of the race track parking lot is connected to the western portion of the Suffolk Downs Station by a small roadway. Race Track patrons arriving via the Suffolk Downs Station are collected at the southern portion of the track parking lot by a race-track bus that takes them directly to the track entrance. Construction worker transport buses could easily pick up workers arriving by the Blue Line at this station location.

The Beachmont Station, though farther from the parking lot entrance, is also within walking distance of the track. Workers getting off at the Beachmont station as well as those choosing to park automobiles at Beachmont station parking facilities could reach the Suffolk Downs Race Track lot by foot if willing to walk a distance of 450 yards along Winthrop Avenue. Most workers accessing buses at the Suffolks Downs Race Track lot would travel by automobile with only a minimal percentage arriving by public transit.

The track can be accessed by automobile from either the Revere Beach Parkway or the Lee-Burbank Highway (Route 1A). Both routes are able to carry high volumes of traffic. The Revere Beach Parkway is commercial and has two through lanes in each direction. Workers traveling westbound are provided

with a left-turn exit lane into the track. Route 1A is a highway with two through lanes in each direction; an exit is accessible in each direction that leads directly into the southwest portion of the race track parking lot; workers traveling on 1A southbound are provided with a left-turn exit lane.

Observation of general traffic conditions in the Suffolk Downs Race Track vicinity has shown adequate traffic flow through intersections and along roadways. Two intersections that could be affected by construction worker automobile traffic have been identified. These intersections are:

1) Lee Burbank Highway and the race track.

2) North Shore Drive, Revere Beach Parkway and the race track.

It is estimated that at least 800 spaces are available for construction worker vehicle parking at any given time. These 800 spaces could generate up to 800 additional vehicles along roadways in the Race Track vicinity during construction shift change intervals. This worst case scenario has been used in analyzing the above intersections. The analysis is described in an attached appendix.

METROPOLITAN DISTRICT COMMISSION LOT

To the north and within walking distance of the Wonderland terminus for the Blue Line, a large paved area lies on the west side of Ocean Avenue. The paved area is large enough to accommodate parking for approximately 600 automobiles, although it is not currently striped and marked for such use.

The space nevertheless currently accommodates approximately 300 automobiles parked daily by commuters who walk from this location to the Wonderland Station platforms. The ground is owned by the Metropolitan District Commission, which provides security surveillance. A contract operator collects a daily fee of $1.00 per day per vehicle.

The unused portion of this paved area could provide a significant amount of parking to accomodate workers bound for the Deer Island site. With paving and striping, approximately 300 spaces could be available for worker automobiles. Most workers accessing buses at the MDC lot would travel by automobile, it is expected that only a minimal percentage will arrive via public transit.

Workers traveling by automobile to the MDC lot would do so via Ocean Avenue. Observation of traffic in the vicinity of the MDC lot shows an adequate flow of traffic along roadways and through intersections. Two intersections that could be affected by construction worker automobile traffic have been identified. These are:

1) Ocean Avenue and Beach Street, and

2) Ocean Avenue and Revere Street.

It is estimated that at least 300 spaces are required for construction worker vehicle parking at any given time. These spaces could generate up to an additional 300 vehicles along roadways in the immediate MDC lot vicinity during construction shift change intervals. This worst case scenario has been used in analyzing the above intersections. The analysis is described in an attached appendix.

BUS SERVICE OPERATING PLAN

Public transport service by bus in Winthrop is currently provided by a privately-owned company named Rapid Transit, Inc. The bus system garage and offices are at 52 Crest Avenue in Winthrop; the fleet of vehicles currently operated is approximately 10.

Two routes within Winthrop are operated, both providing connection to the Orient Heights Station of the MBTA Blue Line. A third route provides connected service by transfer from both of the other routes to Shirley Point and Deer Island.

The two routes through Winthrop respectively serve the downtown center and the Highlands section of town along the northern portion of Route 145. The service to and from Shirley Point operates only to the transfer point in Winthrop Beach.

The transfer among buses occurs in the intersections at Shirley Street and Washington Avenue, and Washington Avenue and Veterans Road. Buses occupy curbside space and wait for connecting arrivals. The presence of the buses causes no observed traffic delay at these locations, even during peak periods of travel. Arrangements for more effective transfer with even less potential impact on traffic flow through the intersections can be made, by using the undeveloped width of Veterans Road just north of Washington Avenue.

Schedules provide base service at intervals that average 30-40 minutes for all routes, with shorter intervals during peak periods of operation:

1) Along the Highlands route in the morning peak, the average service interval is 12 minutes; in the evening peak, 10 minutes.

2) Through Winthrop Center, the morning peak has an average interval of 12 minutes; the evening peak, 10 minutes.

3) For short periods along the Winthrop Center route, the intervals between buses become 7 minutes in the morning peak and 8 minutes in the afternoon peak.

4) The service to and from Point Shirley is approximately 18 minutes on average, during both the morning and afternoon peaks.

Scheduled running time to the Orient Heights Station is approximately 15 minutes at all times of the day. The service does not appear to be heavily used, except on selected movements during the morning or afternoon peak, where buses were observed to be at least two-thirds full. The current Rapid Transit, Inc. one-way fare between Winthrop and Orient Heights is $0.50.

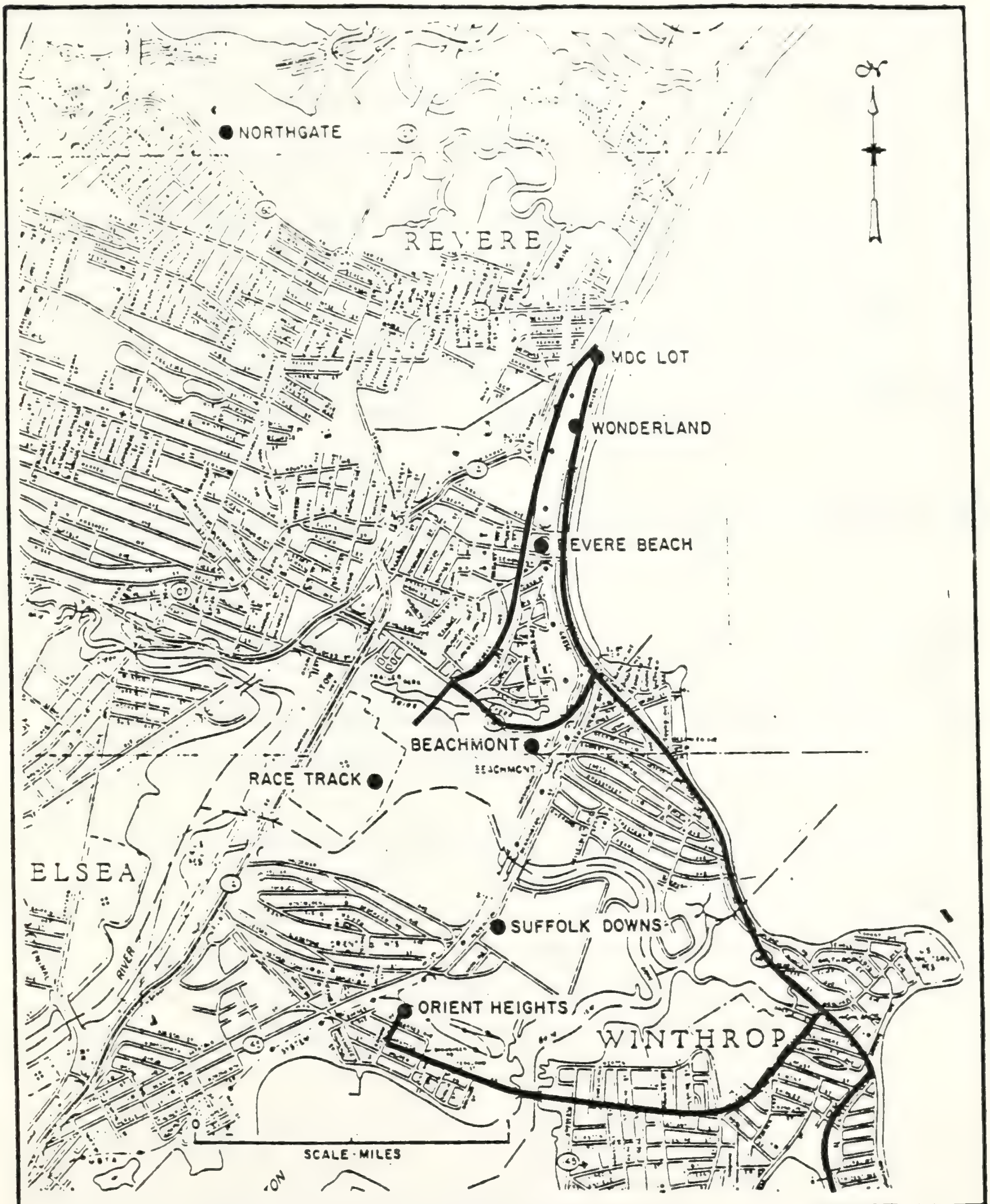
As a regulated private company, the operator has a franchise allowing service to the Orient Heights Station only, with authority to pick up and discharge along Saratoga Street in East Boston between the Winthrop town line and the Orient Heights Station. Use of the Rapid Transit Inc. bus service beyond its current jurisdiction would require extending this existing authority. Action of the Massachusetts DPU would be needed to allow the Company to serve the selected satellite parking facilities. As described in previous sections, three sites have been recommended as suitable satellite areas.

Figure 1 shows the recommended locations and the proposed two bus routes. Route 1 is identical to the existing Highlands Route. The Highlands Route uses Saratoga Street, Main Street, Revere Street, Crest Avenue, Veterans Road, Washington Avenue and Shirley Street for travel between Orient Heights and Winthrop Beach. This existing service could easily be expanded to accommodate additional worker transport requirements. Some Route 1 buses could provide closed door service between Deer Island and Orient Heights during peak worker shift changes to assure efficient transfer of workers using Orient Heights as a commuter transfer point. The roundtrip distance between Orient Heights and Deer Island is 9 miles.

Route 2 would provide service between the MDC Lot, the Race Track and Deer Island. Route 2 would use Shirley Street, Veterans Road, Crest Avenue, Revere Street, Winthrop Avenue, Winthrop Parkway, Ocean Avenue, North Shore Drive and Revere Beach Parkway for travel between the satellite facilities and Deer Island. The roundtrip distance between Deer Island and the satellite facilities is 10.5 miles.

Figure 1

Satellite Parking Sites and Recommended Bus Routes



Worker transport vehicles would be scheduled at intervals throughout the day with shorter intervals during shift changes and longer intervals between shift changes. Typical bus service operations have been defined for transport of workers between Deer Island and the satellite parking areas using the following criteria:

1) On average, two shifts of workers, five days a week will be used to construct facilities.

2) Peak transport periods will occur at the beginning and end of shifts, and transport to and from the site during these peaks will occur during a 90-minute period. The worker transport peak period could overlap into the commuter peak period; however, worker trip travel would be in the opposing direction of commuter travel and would not interfere with commutation riders.

3) Service intervals would not exceed 15 minutes during the peak period.

4) Each satellite parking facility will have no more than two bus stops. Route 2 buses will also stop at the Wonderland and Suffolk Downs Blue Line Stations for transfer of workers using public transit to commute.

5) A base bus service between Deer Island and the satellite areas will be offered throughout the day, to accommodate persons requiring travel to and from Deer Island out of the peak shift change intervals. Personnel traveling to Orient Heights would use the Highland Route scheduled service; a designated bus would service Route 2 during the off-period.

A percentage of the plant construction will require three and four daily shifts for short periods of time. Periodic service schedule revisions will be necessary to accommodate these special worker needs.

Approximately three Route 1 buses and five Route 2 buses are needed in the peak periods to transport workers between Deer Island and satellite facilities. The service interval is respectively 15 minutes and 10 minutes and buses travel at an average speed of 15 mph. Route 1 cycle time is 45 minutes and Route 2 cycle time is 50 minutes including allowance time for bus stop worker transfer. One-way trip travel time between Deer Island and satellite areas would not exceed 30 minutes.

ESTIMATED COSTS

Estimated costs for developing and operating the satellite parking areas, and for operating the bus service are described in the paragraphs below.

Costs for parking facilities development to accommodate Deer Island construction worker vehicles at the three proposed satellite areas are relatively modest. At Orient Heights, the area identified for development is currently unpaved. Improvement work includes initial site preparation, paving and striping. Orient Heights lot development costs are $100,000.

Suffolk Downs development costs include re-paving and re-striping a portion of the lot to provide 300 worker parking spaces. Suffolk Downs Race Track development costs are $600,000.

MDC Lot development costs include repaving and re-striping the lot to provide 300 spaces for worker vehicles. MDC Lot development costs are $600,000.

Costs for operating all three lots include wages for security personnel to assure unauthorized vehicles are not parked in spaces reserved for construction personnel, and that the worker vehicles parked in lots are not vandalized. All the satellite areas will require at least two security personnel with each person working an 8 hour shift. Costs for security

personnel at each lot are $95,000 a year. An extra security shift may be needed during periods when Deer Island Construction is a 24-hour a day operation; this requirement is not included in the above cost.

Costs for bus service operation would be based on a cost per worker trip. Operating costs would be recouped through the aggregate sum of worker-trips generated.

COST-SHARING ALTERNATIVES

The combined capacities of the three chosen sites could provide a significant amount of parking for Deer Island site workers if suitable arrangements for use could be worked out with current management. One possible arrangement might include a fixed fee-per-automobile paid by workers directly to lot attendants.

Another option is to provide workers with automobile stickers that authorize the use of reserved construction worker parking; lump-sum payments to current management for parking lot use could then be made at suitable periodic intervals. At present time, both the Orient Heights and MDC parking lot management charge a daily fee of $1.00 for use of the facilities; general parking at the race-track is free.

Cost of security surveillance at the Orient Heights and MDC Lots could be shared by the Authority and current management; all security costs at the Race Track would be the responsibility of the Authority. Security is currently provided at the Orient Heights and MDC Lots, and is minimal at the Race Track.

Costs for operating the bus service would not be shared by the Authority and the bus company, the bus company would be fairly recompensed for providing the service through worker trip fares. The advantage of this arrangement to the Authority is that the cost-per-worker trip would be minimized by using an already established bus service for worker transport.

PLANT PERSONNEL TRANSPORT

Plant adminstration, operation and maintenance personnel could be transported between Deer Island and a satellite parking area or areas through Winthrop. Table 2 shows the daily plant personnel requirements. Approximately 480 workers per day must be transported to Deer Island.

Table 2

Permanent Daily Plant Personnel Requirements

	Shift Workers
Total Staff	480
12 AM to 8 AM	19
8 AM to 4 PM	404
4 PM to 12 PM	19

Both the Suffolk Downs Race Track and MDC Lot have space to accomodate Plant personnel parking requirements. Either one or both lots could be used as a permanent parking facility provided suitable arrangements for permanent use of the sites could be worked out with current management.

APPENDIX A

Appendix A
Method of Analysis

The volume of traffic that can pass over a given roadway is largely a function of the speed at which traffic moves. Given normal driver reaction, speeds decline as traffic volume increases; maximum throughput usually occurs at speeds ranging from 30 to 40 mph.

Determinants of capacity vary for different types of facilities. In general, freeway capacity is a function of lane width, number of lanes provided, availability of improved shoulders and sight lines. For arterials, capabilities at intersections where conflicting movements can occur are usually the determinant of capacity; this is especially true in heavily-travelled corridors. Under principles of analysis established through the work of the Transportation Research Board, the maximum volume that can occur under the conditions described above is generally taken as representing the capacity of the particular facility under examination.

The potential impact on particular intersections in East Boston and Revere that will be affected most directly by the Deer Island construction traffic has been examined, to establish whether new intersection delay could cause significant local distress. The purpose in these assessments has been to identify potential changes of service level at intersections.

Because of the need for recognition of local traffic conditions in estimates of highway performance, the Transportation Research Board in 1965 adopted a defined series of Service Levels that could be used in comparative assessments of the degree to which highway facilities accommodate traffic. These Levels of Service have had wide acceptance and application since 1965.

To measure the performance of existing or proposed highway facilities, the ratio of projected volume to available capacity has been commonly used. The numerator and denominator of this ratio are usually measured in terms of hourly vehicular flows, and a value of unity for the ratio is accepted as an indication that traffic volume fills the available capacity of a facility. Ratios larger than unity imply traffic volume in excess of available capacity, moving under forced flow conditions at slow speed. A ratio having a value less than unity means that volume has not yet reached capacity and that more acceptable traffic conditions prevail.

In 1985, the Transportation Research Board issued a revised Highway Capacity Manual that expanded the above service level definition to include vehicular delay concepts for signalized intersections as well as a procedure for use in estimating service levels at unsignalized intersections. A brief discussion of the methods contained in the 1985 Highway Capacity Manual is presented in the paragraphs below.

Signalized intersection performance is currently measured using both vehicular capacity and delay concepts. The capacity of an intersection and its associated delays are dependent on the intersection geometry, signal phasing, volume and pattern of traffic movements, and other factors such as the presence of curbside parking and pedestrian traffic. Both capacity and delay must now be examined for a complete assessment of the intersection.

The intersection capacity is derived by multiplying an established ideal intersection saturation flow rate with adjustment factors that account for lane width and number, heavy vehicles present, grade, parking maneuvers, bus blockage, area type, right turns and left turns. The adjusted value is then multiplied by the ratio of green time available for the movement in question to total cycle length to obtain approach capacity. The result is related to the volumes present in the form of a ratio of volume to capacity, (V/C).

The parameter of interest is the critical V/C ratio for the intersection. The critical V/C ratio indicates the proportion of available capacity in use by vehicles occupying critical lane groups. In general, the critical lane group is the lane or lanes moving during a phase that generates the highest ratio of flow rate to adjusted saturation flow, (V/S). The critical V/S ratios for each phase are summed, and then multiplied by the signal cycle length. This value is then divided by the cycle length minus the cycle time portion where movement is not allowed on any intersection approach, to yield the critical V/C ratio.

A critical V/C ratio of less than 1.00 indicates that the intersection geometry, cycle length and phase plan are adequate to handle all critical flows without demand exceeding capacity. A ratio greater than 1.00 indicates intersection changes may be warranted because of oversaturation conditions.

Intersection service level is related to the average stopped delay per vehicle. Delay is a function of cycle length, available green time, the V/C ratio and capacity. The level of service can be defined for lane groups within an approach, for each approach and for the entire intersection. The relation of service level to vehicular delay is shown in Table 1.

Table 1

Signalized Intersection Service Level Criteria

Level of Service	Stopped Delay per Vehicle (secs)
A	0.0 to 5.0
B	5.1 to 15.0
C	15.1 to 25.0
D	25.1 to 40.0
E	40.1 to 60.0
F	60.1 and greater

In the absence of congestion, the expected value of stopped delay obtained from the 1985 methods is dependent primarily on the signal cycle and phasing. The resultant level of service thus can be improved within limits by adjustments of signal timing and is <u>not</u> solely a reflection of traffic volume.

Capacity at unsignalized intersections is controlled by the distribution of gaps in the major street traffic stream and driver judgement in selecting gaps for executing desired maneuvers. The analysis method is based on the following criteria:

1) Major street traffic is generally not affected by minor street flows in uncongested traffic.

2) Where congestion does occur, it is likely that major flows will experience some impedance from minor street traffic.

3) Left turns from the major street are affected by the opposing major street flow.

4) Minor street traffic is affected by all major street movements and conflicting movements.

The method also adjusts for additional impedance of minor street flows on each other, and accounts for shared use of lanes. The method presumes that intersection control is provided on the minor street; this presumption has been used in the analysis.

Intersection service level is a function of the calculated reserve capacity for each lane of the minor street intersection approaches, and for approach left turn movements on the major street. An overall service level is not defined for unsignalized intersections. Table 2 shows service level criteria for unsignalized intersections.

The Transportation Research Board Levels of Service represent qualitative standards of the overall ability of defined highway facilities to satisfy motorists' desires at different times of the day and in relation to various levels of average operating speed, safety, freedom of maneuver, traffic mix and operating cost. Standard Levels of Service have been defined

Table 2

Unsignalized Intersection Service Level Criteria

Reserve Capacity (pssngr cars/pr hr)	Level of Service	Expected Delay to Minor Street Traffic
400 and greater	A	Little or no delay
300-399	B	Short traffic delays
200-299	C	Average traffic delays
100-199	D	Long traffic delays
0- 99	E	Very long traffic delays
*	F	*

*When demand exceeds the capacity of the lane, extreme delays will be encountered with queuing which may cause severe congestion affecting other traffic movements in the intersection.

for limited-access facilities and for urban and rural arterials. The requirements for the several Levels of Service give recognition to the number of lanes available for travel, degree of intersection interference, lane width and other aspects of highway geometry and control.

In general, the defined Levels of Service A, B, and C describe traffic volumes, that are sufficiently low as to provide free and stable flow of traffic at attractive operating speeds. Service Level D usually describes a volume for given facilities that would cause unstable flow conditions to be approached, at reduced and less attractive operating speeds. Service levels E and F usually connote excessive volumes, unstable or forced flow conditions, high levels of delay and unattractive operating speeds.

Computer-based methods of analysis have been used, allowing specific consideration of the magnitude and composition of traffic flows from each approach entering an intersection. Specific 15-minute peaking relationships are recognized for each approach. Estimates of capacity, the ratio of volume to capacity, service level and delay have been prepared for each lane group at each intersection, and for each intersection as a whole.

Through iterative application of the analysis to existing conditions and to conditions that will exist with the new plant under construction, the differential impact that will be experienced at each location as a result of the change in truck flows has been identified.

The methods used in the analysis are completely consistent with American traffic engineering practice. The details of method and data applied in each case are set forth in a description of the investigations performed for each intersection that appears later in this report.

APPENDIX B

Appendix B

Intersection Analysis

Analyses have been performed for street intersections potentially affected by Deer Island construction worker traffic to and from satellite parking sites. Existing condition intersection traffic volumes were estimated using recent traffic count data; Deer Island construction worker movements were estimated under worst-case conditions.

All intersections have been analyzed with no changes in existing cartway width, curbside parking practice or intersection control. The intersections most potentially affected by Deer Island construction worker satellite parking are listed in Table B-1. The table shows that three of the intersections are operating as unsignalized and that two intersections are under phased control. These intersections have been selected because they are adjacent to satellite parking points of ingress and egress, resulting in the likelihood that a majority of construction worker vehicles will pass through these intersections. Intersections that are situated further away may not necessarily be impacted by worker vehicle movements because workers are not constrained to travel over only one designated route to the sites. The paragraphs below summarize the peak-hour traffic volumes at each intersection.

Table B-1

Street Intersections Potentially Affected By Deer Island Satellite Parking

Intersections	Phased Control	Satellite Facility
Bennington Street/Saratoga Street	Yes	Orient Heights Station
North Shore Road/Revere Beach Parkway	Yes	Suffolk Downs Race Track
Lee Burbank Highway/Suffolk Downs Race Track	No	Suffolk Downs Race Track
Ocean Avenue/Beach Street	No	MDC lot
Ocean Avenue/Revere Street	No	MDC lot

1) <u>Bennington Street and Saratoga Street</u> - The peak hour at this location occurs between 5:00 and 6:00 PM. The largest peak hour volumes occur on the Bennington Street southbound and northbound approaches. The total peak-hour volume for the intersection is 2,250; and the signal cycle time is 111 seconds.

2) <u>Lee Burbank Highway and Suffolk Downs Race Track</u> - The peak hour at this location occurs between 4:30 and 5:30 PM. The largest peak hour volumes occur on the Lee Burbank Highway southbound and northbound approaches. The total peak-hour volume for the intersection is 3,507; and the intersection is currently uncontrolled. However, phased signals are located 475-ft north of and 1,375-ft south of the racetrack entrance.

3) <u>North Shore Road and Revere Beach Parkway</u> - The peak hour at this location occurs between 4:45 and 5:45 PM. The largest peak hour volumes occur on the Revere Beach Parkway eastbound and westbound approaches. The total peak-hour volume for the intersection is 3,594; and the signal maximum cycle time is 246 seconds.

4) <u>Ocean Avenue and Beach Street</u> - The peak hour at this location occurs in the morning. The largest peak hour volumes occur on the Ocean Avenue southbound and the Beach Street eastbound approaches. The total peak-hour volume for the intersection is 1,050; and the intersection is currently uncontrolled.

5) <u>Ocean Avenue and Revere Street</u> - The peak hour at this location occurs between 7:00 and 8:00 AM. The largest peak hour volumes occur on the Revere Street westbound approach. The total peak-hour volume for the intersection is 1,099; and the intersection is currently uncontrolled.

Table B-2 summarizes the existing condition service levels. The table shows the intersection peak traffic volumes, effective capacity, signal cycle time, estimated overall Service Level and computed average delay for each intersection under existing conditions. The table also shows that uncontrolled intersection minor streets are already operating at Service Level C or less. These intersections have been further analyzed under phased control to ascertain whether service levels on minor streets could be improved without significant impact on major street traffic. In all cases, service

Table B-2
Existing Condition Service Levels

Unsignalized Intersections

	Major Street						Minor Street					
Intersection	Drctn	Rsrv Cpcty	Srvc Lvl	Drctn	Rsrv Cpcty	Srvc Lvl	Drctn	Rsrv Cpcty	Srvc Lvl	Drctn	Rsrv Cpcty	Srvc Lvl
*Revere/Ocean	WB	411	A				NB	31	E			
*Ocean/Beach	SB	583	A				WB	205	C	EB Lt	142	D
*Route 1A/ Race Track	SB	275	C				WB Lt	-113	F	WB Rt	81	D

*Major Street/Minor Street

Signalized Intersections

Intersection	Peak Hour Volume (vhcls)	Capacity (vhcls)	V/C	Crtcl V/C	Cycle Length (secs)	Overall Srvc Lvl	Avg Delay Per Vhcl (secs)
Bennington/ Saratoga	2,461	4,576	.54	.63	111	C	23.5
Route 1A/ Race Track	3,133	5,713	.56	.77	80	C	18.7
North Shore/ Revere, Racetrack							
Revere/Ocean	1,314	4,435	.30	.25	80	B	10.9
Ocean/Beach	1,167	3,278	.36	.48	85	B	14.6

levels are improved on minor street approaches. The Route 1A and race track overall service level is C; however, installing an activated signal that only increases available green time on the race track approach when warranted by traffic volumes will mitigate vehicular delays on Route 1A. Appendix C contains the existing condition service level analyses.

Each intersection has been further examined under future conditions that account for Deer Island construction workers traveling to and from satellite parking sites. Future conditions used in the analysis are described by intersection in the paragraphs below.

Worst-case conditions for Orient Heights include 50 Deer Island construction worker automobiles moving through the intersection of Bennington and Saratoga Streets. Worst-case conditions for the Suffolk Downs Race Track include 280 Shift-1 Deer Island construction worker automobiles and 120 Shift-2 worker automobiles moving through the intersections of the Lee Burbank Highway and the Suffolk Downs Racetrack entrance, and North Shore Road and the Revere Beach Parkway. In analyzing these two intersections, it has been estimated that one-half the expected worker volume would access the race track at each entrance. Worst-case conditions for the MDC lot include 210 Shift-1 Deer Island Construction worker and 90 Shift-2 worker automobiles moving through the intersections of Ocean Avenue and Beach Street, and Ocean Avenue and Revere Street.

Table B-3 summarizes future condition service levels for each of the three satellite parking sites. The table shows the intersection peak traffic volumes, effective capacity, signal cycle time, estimated overall Service Level and computed average delay for each intersection under estimated future conditions. The table shows that service levels remain unchanged except for the Ocean Avenue and Beach Street intersections which decreases from B to C. However, overall vehicular delay is only increased 1.5 seconds per vehicle on average. Appendix D contains the future condition service level analyses.

Table B-3

Future Condition Service Levels

Intersection	Adjusted Peak Hour Volume (vhcls)	Capacity (vhcls)	V/C	Crtcl V/C	Cycle Length (secs)	Overall Srvc Lvl	Avg Delay Per Vhcl (secs)
Bennington/ Saratoga	2562	4576	.56	.64	111	C	24.3
Route 1A/ Race Track	3995	6225	.64	.90	90	C	20.1
Revere Parkway/ Northshore/ Racetrack	(later)						
*Revere/ Ocean	1558	4435	.35	.30	80	B	11.5
*Ocean/ Beach	1478	3207	.46	.74	85	C	16.1

*Currently operating as unsignalized.

APPENDIX C

UNSIGNALIZED INTERSECTION ANALYSIS

MWRA Deer Island WWTP

Project 319, FJH 28 Mar 88

ROUTE 1A AND SUFFOLK DOWNS RACE TRACK - PM PEAK

VOLUME ADJUSTMENTS

MVMNT	ADJSTD VOLUME
V2	1280
V3	24
V4	0
V5	0
V7	263
V9	136

STEP 1: RT FROM MINOR STREET		V9
Conflicting flows, Vc		1292.00
Critical gap, Tc	*	5.50
Potential Capacity, Cp	*	225.00
Actual Capacity, Cm		225.00

STEP 2: LT FROM MAJOR STREET		V4
Conflicting flows, Vc		1304.00
Critical gap, Tc	*	5.00
Potential Capacity, Cp	*	275.00
Percent of Cp used		0.00%
Impedance Factor, P	*	1.00
Actual Capacity, Cm		275.00

STEP 3: LT FROM MINOR STREET		V7
Conflicting flows, Vc		1292.00
Critical gap, Tc	*	6.50
Potential Capacity, Cp	*	150.00
Actual Capacity, Cm		150.00

LEVEL OF SERVICE CALCULATION

MOVMENT	VOLUME	Cm	Csh	Cr	LOS
V7	263	150		-113	F
V9	136	225		89	E
V4	0	275		275	C

UNSIGNALIZED INTERSECTION ANALYSIS

MWRA Deer Island WWTP

Project 319, FJH 08 Mar 88

OCEAN AVENUE AND BEACH STREET - AM PEAK

VOLUME ADJUSTMENTS

MVMNT	VOLUME
V1	0
V2	789
V3	155
V4	22
V5	44
V6	0
V7	44
V8	0
V9	56
V10	0
V11	56
V12	0

STEP 1: RT FROM MINOR STREET		V9	V12
Conflicting flows, Vc		866.50	44.00
Critical gap, Tc	*	5.50	5.50
Potential Capacity, Cp	*	390.00	1000.00
Percent of Cp used		14.36%	0.00%
Impedance Factor, P	*	0.90	1.00
Actual Capacity, Cm		390.00	1000.00

STEP 2: LT FROM MAJOR STREET		V4	V1
Conflicting flows, Vc		944.00	44.00
Critical gap, Tc	*	5.00	5.00
Potential Capacity, Cp	*	420.00	1000.00
Percent of Cp used		5.24%	0.00%
Impedance Factor, P	*	0.95	1.00
Actual Capacity, Cm		420.00	1000.00

STEP 3: TH FROM MINOR STREET		V8	V11
Conflicting flows, Vc		932.50	1010.00
Critical gap, Tc	*	6.00	6.00
Potential Capacity, Cp	*	290.00	275.00
Percent of Cp used		0.00%	20.36%
Impedance Factor, P	*	1.00	0.85
Actual Capacity, Cm		275.50	261.25

STEP 4: LT FROM MINOR STREET		V7	V10
Conflicting flows, Vc		988.5	1066
Critical gap, Tc	*	6.5	6.5
Potential Capacity, Cp	*	230	210
Actual Capacity, Cm		185.73	179.55

LEVEL OF SERVICE CALCULATION

MOVMENT	VOLUME	Cm	Csh	Cr	LOS
V7	44	186		142	D
V8	0	276			
V9	56	390		334	B
V1	0	1000		1000	A
V4	22	420		398	B
V10	0	180			
			261	205	
V11	56	261			
			261	205	
V12	0	1000			
			261	205	C

UNSIGNALIZED INTERSECTION ANALYSIS

MWRA Deer Island WWTP

Project 319, FJH 28 Mar 88

OCEAN AVENUE AND REVERE STREET - AM PEAK

VOLUME ADJUSTMENTS

MVMNT	ADJSTD VOLUME
V2	0
V3	268
V4	689
V5	284
V7	89
V9	0

STEP 1: RT FROM MINOR STREET		V9
Conflicting flows, Vc		0.00
Critical gap, Tc	*	5.50
Potential Capacity, Cp	*	1000.00
Actual Capacity, Cm		1000.00

STEP 2: LT FROM MAJOR STREET		V4
Conflicting flows, Vc		89.00
Critical gap, Tc	*	5.00
Potential Capacity, Cp	*	1100.00
Percent of Cp used		62.64%
Impedance Factor, P	*	0.48
Actual Capacity, Cm		1100.00

STEP 3: LT FROM MINOR STREET		V7
Conflicting flows, Vc		973.00
Critical gap, Tc	*	6.50
Potential Capacity, Cp	*	250.00
Actual Capacity, Cm		120.00

LEVEL OF SERVICE CALCULATION

MOVMENT	VOLUME	Cm	Csh	Cr	LOS
V7	89	120		31	E
V9	0	1000			
V4	689	1100		411	A

SIGNALIZED INTERSECTION ANALYSIS

MWRA Deer Island WWTP

LEE BURBANK (RT 1A) AND RACE TRACK

LANE GROUPS	LANE NMBR	LANE WDTH	APPRCH VOLUME	RIGHT NO	RIGHT %	LEFT NO	LEFT %	TRUCKS NO	TRUCKS %	PEAK FCTR	ADJSTD VOLUME	G/C RATIO	PEDS /HR	PRKNG ALLWD	GRADE
RT 1A NB SR	2	11	1962	24	1%	0	0%	63	3.2%	1.00	1962	0.58	10	N	0%
RT 1A SB S	2	11	1131	0	0%	0	0%	28	2.5%	1.06	1199	0.58	10	N	0%
RT 1A SB L	1	10	4	0	0%	4	100%	0	0.0%	1.06	4	0.58	10	N	0%
Race Track LR	2	12	360	123	34%	237	66%	0	0.0%	1.11	400	0.33	10	N	0%

SATURATION FLOWS	LANE NMBR	LANE WDTH	IDEAL STRTN FLOW	LANE FCTR Fw	TRCK FCTR Fhv	GRADE FCTR Fg	PRKNG FCTR Fp	BUS FCTR Fbb	AREA FCTR Fa	RGHT FCTR Frt	LEFT FCTR Flt	STRTN FLOW CLCTN
RT 1A NB SR	2	11	1800	0.97	0.983	1	1.00	1.00	1.0	1.00	1.00	3427
RT 1A SB S	2	11	1800	0.97	0.987	1	1.00	1.00	1.0	1.00	1.00	3447
RT 1A SB L	1	10	1800	0.93	1.000	1	1.00	1.00	1.0	1.00	0.62	1035
Race Track LR	2	12	1800	1.00	1.000	1	1.00	1.00	1.0	0.95	0.95	3250

CAPACITY ANALYSIS	ADJ FLOW	ADJ SAT	V/S	G/C	CPCTY C	V/C	CRTCL LANE
RT 1A NB SR	1962	3426	0.57	0.58	1987	0.99	Y
RT 1A SB S	1199	3446	0.35	0.58	1999	0.60	
RT 1A SB L	4	1035	0.00	0.58	600	0.01	
Race Track LR	400	3250	0.12	0.33	1073	0.37	Y

Cycle Length (sec): 80 Summation V/S: 0.70
Lost Time (sec): 8 V/C Critical: 0.77

VEHICLE DELAY	V/C	G/C	CYCLE LENGTH	DELAY ONE	CPCTY	DELAY TWO	PF	TOTAL DELAY	LOS
RT 1A NB SR	0.98	0.58	80	12.5	1987	13.0	1	25.5	D
RT 1A SB S	0.59	0.58	80	8.22	1999	0.37	1	8.59	B
RT 1A SB L	0.00	0.58	80	5.38	600	0.00	1	5.38	B
Race Track LR	0.37	0.33	80	15.5	1073	0.10	1	15.6	B

INTERSECTION SERVICE LEVEL DELAY: 18.7 C

LEFT TURN ADJUSTMENT FACTOR

Project 319, FJH 28 Mar 88

INPUT VARIABLES	EB	WB	SB	NB
Cycle length C(secs)			80	
Effctv Green G(secs)			26	
Lane Number N			1	
Ttl Approach Flow Rt Va			4	
Mainline Flow Rate Vm			0	
Left-turn Flow Rate Vlt			4	
Proportion of Left Plt			1	
Opposing lane number No			2	
Opposing flow rate Vo			1962	
Proportion lft oppsng flw Plto			0	

COMPUTATIONS	
Sop	3600
Yo	0.55
Gu	-38.68
Fs	-0.35
Pl	1.00
Gq	64.68
Pt	0.00
Gf	0.00
El	-3.20
Fm	0.62
Flt	0.62

ROUTE 1A NB RT 1A SB

RACE TRACK WB

SIGNALIZED INTERSECTION ANALYSIS

MWRA Deer Island WWTP

REVERE AND OCEAN - AM PEAK

Project 319, FJH 28 Mar 88

LANE GROUPS	LANE NMBR	LANE WDTH	APPRCH VOLUME	RIGHT NO	RIGHT %	LEFT NO	LEFT %	TRUCKS NO	TRUCKS %	PEAK FCTR	ADJSTD VOLUME	G/C RATIO	PEDS /HR	PRKNG ALLWD	GRADE
Revere WB SL	3	12	834	0	0%	594	71%	5	0.6%	1.16	967	0.45	10	Y	0%
Revere EB R	2	9	207	207	100%	0	0%	4	1.9%	1.27	263	0.45	10	Y	0%
Ocean NB L	1	12	58	0	0%	58	100%	4	6.9%	1.44	84	0.45	10	Y	0%

SATURATION FLOWS	LANE NMBR	LANE WDTH	IDEAL STRTN FLOW	LANE FCTR Fw	TRCK FCTR Fhv	GRADE FCTR Fg	PRKNG FCTR Fp	BUS FCTR Fbb	AREA FCTR Fa	RGHT FCTR Frt	LEFT FCTR Flt	STRTN FLOW CLCTN
Revere WB SL	3	12	1800	1.00	0.998	1	1.00	1.00	1.0	1.00	1.00	5389
Revere EB R	2	9	1800	0.90	0.991	1	1.00	1.00	1.0	0.85	1.00	2729
Ocean NB L	1	12	1800	1.00	0.965	1	1.00	1.00	1.0	1.00	1.00	1737

CAPACITY ANALYSIS	ADJ FLOW	ADJ SAT	V/S	G/C	CPCTY C	V/C	CRTCL LANE
Revere WB SL	967	5389	0.18	0.45	2425	0.40	Y
Revere EB R	263	2729	0.10	0.45	1228	0.21	
Ocean NB L	84	1737	0.05	0.45	782	0.11	Y

Cycle Length (sec): 80   Summation V/S: 0.23
Lost Time (sec): 8   V/C Critical: 0.25

VEHICLE DELAY	V/C	G/C	CYCLE LENGTH	DELAY ONE	CPCTY	DELAY TWO	PF	TOTAL DELAY	LOS
Revere WB SL	0.39	0.45	80	11.2	2425	0.06	1	11.2	B
Revere EB R	0.21	0.45	80	10.1	1228	0.01	1	10.1	B
Ocean NB L	0.10	0.45	80	9.66	782	0.00	1	9.66	B
			INTERSECTION SERVICE LEVEL DELAY:					10.9	B

LEFT TURN ADJUSTMENT FACTOR

INPUT VARIABLES	EB	WB	NB	SB
Cycle length C(secs)				
Effctv Green G(secs)				
Lane Number N				
Ttl Approach Flow Rt Va				
Mainline Flow Rate Vm				
Left-turn Flow Rate Vlt				
Proportion of Left Plt				
Opposing lane number No				
Opposing flow rate Vo				
Proportion lft oppsng flw Plto				

COMPUTATIONS

Sop
Yo
Gu
Fs
Pl
Gq
Pt
Gf
El
6 Fm
Flt

REVERE EB   REVERE WB

OCEAN NB

SIGNALIZED INTERSECTION ANALYSIS

MWRA Deer Island WWTP

OCEAN AND BEACH - AM PEAK

LANE GROUPS	LANE NMBR	LANE WDTH	APPRCH VOLUME	RIGHT NO	RIGHT %	LEFT NO	LEFT %	TRUCKS NO	TRUCKS %	PEAK FCTR	ADJSTD VOLUME	G/C RATIO	PEDS /HR	PRKNG ALLWD	GRADE
Ocean NB SL	2	10	60	0	0%	20	33%	1	2.0%	1.11	67	0.48	10	Y	0%
Ocean SB SR	2	10	850	140	16%	0	0%	17	2.0%	1.11	944	0.48	10	Y	0%
Beach EB RL	1	15	90	40	44%	50	56%	2	2.0%	1.11	100	0.42	10	Y	0%
Beach WB SRL	2	10	50	0	0%	0	0%	1	2.0%	1.11	56	0.42	10	N	0%

SATURATION FLOWS	LANE NMBR	LANE WDTH	IDEAL STRTN FLOW	LANE FCTR Fw	TRCK FCTR Fhv	GRADE FCTR Fg	PRKNG FCTR Fp	BUS FCTR Fbb	AREA FCTR Fa	RGHT FCTR Frt	LEFT FCTR Flt	STRTN FLOW CLCTN
Ocean NB SL	2	10	1800	0.93	0.990	1	0.90	1.000	1.0	1.00	0.19	552
Ocean SB SR	2	10	1800	0.93	0.990	1	0.90	1.000	1.0	0.88	1.00	2616
Beach EB RL	1	15	1800	1.10	0.990	1	0.90	1.000	1.0	0.84	0.92	1355
Beach WB SRL	2	10	1800	0.93	0.990	1	0.90	1.000	1.0	0.90	1.00	2685

CAPACITY ANALYSIS	ADJ FLOW	ADJ SAT	V/S	G/C	CPCTY C	V/C	CRTCL LANE
Ocean NB SL	67	552.	0.12	0.48	265	0.25	
Ocean SB SR	944	2616	0.36	0.48	1256	0.75	Y
Beach EB RL	100	1355	0.07	0.42	569	0.18	Y
Beach WB SRL	56	2685	0.02	0.42	1128	0.05	

Cycle Length (sec): 85 Summation V/S: 0.43
Lost Time (sec): 8 V/C Critical: 0.48

INTERSECTION DELAY	V/C	G/C	CYCLE LENGTH	DELAY ONE	CPCTY	DELAY TWO	PF	TOTAL DELAY	LOS
Ocean NB SL	0.25	0.48	85	9.93	265	0.10	1	10.0	B
Ocean SB SR	0.75	0.48	85	13.6	1256	1.81	1	15.4	C
Beach EB RL	0.17	0.42	85	11.7	569	0.01	1	11.7	B
Beach WB SRL	0.04	0.42	85	11.0	1128	0.00	1	11.0	B

INTERSECTION SERVICE LEVEL DELAY: 14.6 B

LEFT TURN ADJUSTMENT FACTOR

Project 319, FJH 28 Mar 88

INPUT VARIABLES	NB	SB	EB	WB
Cycle length C(secs)	85		85	
Effctv Green G(secs)	41		36	
Lane Number N	1		1	
Ttl Approach Flow Rt Va	60		90	
Mainline Flow Rate Vm	40		40	
Left-turn Flow Rate Vlt	20		50	
Proportion of Left Plt	0.33		0.56	
Opposing lane number No	1		1	
Opposing flow rate Vo	850		50	
Proportion lft oppsng flw Plto	0.00		0.00	

COMPUTATIONS	NB	SB	EB	WB
Sop	1800.00		1800.00	
Yo	0.47		0.03	
Gu	1.63		34.60	
Fs	0.34		0.84	
Pl	0.33		0.56	
Gq	39.37		1.40	
Pt	0.67		0.44	
Gf	4.00		0.69	
El	3.27		1.33	
Fm	0.19		0.92	
Flt	0.19		0.92	

```
                  : VETERANS      :
                  :               :
                  : V1 LT SB      :
                  : V2 TH SB      :
          SHIRLEY : V3 RT SB      :
 ----------------                 ---------
        V7 LT EB                  V10 LT WB
        V8 TH EB                  V11 TH WB
        V9 RT EB                  V12 RT WB
 ----------------                 ---------
                  : V4 LT NB      :
                  : V5 TH NB      :
                  : V6 RT NB      :
                  :               :
                  :               :
                  :               :
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SIGNALIZED INTERSECTION ANALYSIS

BENNINGTON AND SARATOGA

LANE GROUPS	LANE NMBR	LANE WDTH	APPRCH VOLUME	RIGHT NO	RIGHT %	LEFT NO	LEFT %	TRUCKS NO	TRUCKS %	PEAK FCTR	ADJSTD VOLUME	G/C RATIO	PEDS /HR	PRKNG ALLWD	GRADE
Bennington SB L	1	13	103	0	0%	103	100%	1	1.0%	1.02	105	0.29	0	Y	0%
Bennington SB SR	1	13	193	41	21%	0	0%	9	4.7%	1.02	197	0.29	0	Y	0%
Bennington NB SRL	2	13	665	331	50%	27	4%	7	1.1%	1.10	732	0.29	0	Y	0%
Bennington NB R	1	13	331	331	100%	0	0%	13	3.9%	1.10	364	0.42	0	Y	0%
Saratoga WB L prtctd	1	11	145	0	0%	145	100%	2	1.4%	1.08	157	0.39	0	N	0%
Saratoga WB L prmttd	1	11	145	0	0%	145	100%	2	1.4%	1.08	157	0.26	0	N	0%
Saratoga WB SR	1	11	343	149	43%	0	0%	7	2.0%	1.08	370	0.65	0	N	0%
Saratoga EB SRL	2	10	335	12	4%	40	12%	0	0.0%	1.13	379	0.23	0	Y	0%

SATURATION FLOWS	LANE NMBR	LANE WDTH	IDEAL STRTN FLOW	LANE FCTR Fw	TRCK FCTR Fhv	GRADE FCTR Fg	PRKNG FCTR Fp	BUS FCTR Fbb	AREA FCTR Fa	RGHT FCTR Frt	LEFT FCTR Flt	STRTN FLOW CLCTN
Bennington SB L	1	13	1800	1.03	0.995	1	0.90	1.000	1.00	1.00	0.57	939
Bennington SB SR	1	13	1800	1.03	0.970	1	0.90	1.000	1.00	0.97	1.00	1567
Bennington NB SRL	2	13	1800	1.03	0.988	1	0.90	1.000	1.00	0.93	1.00	3051
Bennington NB R	1	13	1800	1.03	0.980	1	0.90	1.000	1.00	0.85	1.00	1390
Saratoga WB L prtctd	1	11	1800	0.97	0.995	1	1.00	1.000	1.00	1.00	0.59	1027
Saratoga WB L prmttd	1	11	1800	0.97	0.995	1	1.00	1.000	1.00	1.00	0.59	1025
Saratoga WB SR	1	11	1800	0.97	0.990	1	1.00	1.000	1.00	0.93	1.00	1616
Saratoga EB SRL	2	10	1800	0.93	1.000	1	0.90	1.000	1.00	0.99	0.96	2890

CAPACITY ANALYSIS	ADJ FLOW	ADJ SAT	V/S	G/C	CPCTY C	V/C	CRTCL LANE
Bennington SB L	105	939	0.11	0.29	272	0.39	
Bennington SB SR	197	1567	0.13	0.29	454	0.43	
Bennington NB SRL	732	3051	0.24	0.29	885	0.83	
Bennington NB R	364	1390	0.26	0.42	584	0.62	Y
Saratoga WB L prtctd	157	1027	0.15	0.39	400	0.39	
Saratoga WB L prmttd	157	1025	0.15	0.26	266	0.59	
Saratoga WB SR	370	1616	0.23	0.65	1050	0.35	Y
Saratoga EB SRL	379	2890	0.13	0.23	665	0.57	Y

Cycle Length (sec): 111 Summation V/S: 0.62
Lost Time (sec): 2 V/C Critical: 0.63

INTERSECTION DELAY	V/C	G/C	CYCLE LENGTH	DELAY ONE	CPCTY	DELAY TWO	PF	TOTAL DELAY	LOS
Bennington SB L	0.38	0.29	111	23.9	272	0.46	1	24.4	C
Bennington SB SR	0.43	0.29	111	24.3	454	0.43	1	24.7	C
Bennington NB SRL	0.82	0.29	111	27.9	885	4.58	1	32.5	D
Bennington NB R	0.62	0.42	111	19.2	584	1.48	1	20.7	C
Saratoga WB L prtctd	0.39	0.39	111	18.5	400	0.33	1	18.8	C
Saratoga WB L prmttd	0.58	0.26	111	27.2	266	2.43	1	29.6	D
Saratoga WB SR	0.35	0.65	111	6.70	1050	0.08	1	6.79	B
Saratoga EB SRL	0.56	0.23	111	28.7	665	0.87	1	29.6	D

INTERSECTION SERVICE LEVEL DELAY: 23.5 C

LEFT TURN ADJUSTMENT FACTOR Project 319, FJM 14 Jan 87

INPUT VARIABLES	NB	SB	EB	WB
Cycle length C(secs)	111	111	111	111
Effctv Green G(secs)	32	32	25	29
Lane Number N	2	1	2	1
Ttl Approach Flow Rt Va	665	103	335	145
Mainline Flow Rate Vm	638	0	295	0
Left-turn Flow Rate Vlt	27	103	40	145
Proportion of Left Plt	0.04	1.00	0.12	1.00
Opposing lane number No	2	2	2	2
Opposing flow rate Vo	193	334	192	295
Proportion lft oppsng flw Plto	0.00	0.04	0.00	0.12

COMPUTATIONS

	NB	SB	EB	WB
Sop	3600.00	3559.32	3600.00	3481.24
Yo	0.05	0.09	0.05	0.08
Gu	27.52	23.82	20.15	21.41
Fs	0.75	0.67	0.76	0.69
Pl	0.09	1.00	0.27	1.00
Gq	4.48	8.18	4.85	7.59
Pt	0.91	0.00	0.73	0.00
Gf	3.83	0.00	2.88	0.00
El	1.49	1.69	1.49	1.63
Fm	1.01	0.57	0.93	0.59
Flt	1.01	0.57	0.96	0.59

BENNINGTON SB

SARATOGA EB

APPENDIX D

SIGNALIZED INTERSECTION ANALYSIS

MWRA Deer Island WWTP

LEE BURBANK (RT 1A) AND RACE TRACK - FUTURE CONDITION, AUTOMOBILES MOVING WB LT & NB RT

LANE GROUPS	LANE NMBR	LANE WDTH	APPRCH VOLUME	RIGHT NO	RIGHT %	LEFT NO	LEFT %	TRUCKS NO	TRUCKS %	PEAK FCTR	ADJSTD VOLUME	G/C RATIO	PEDS /HR	PRKNG ALLWD	GRADE
RT 1A NB SR	2	11	2082	144	7%	0	0%	63	3.0%	1.00	2082	0.62	10	N	0%
RT 1A SB S	2	11	1131	0	0%	0	0%	28	2.5%	1.06	1199	0.62	10	N	0%
RT 1A SB L	1	10	4	0	0%	4	100%	0	0.0%	1.06	4	0.62	10	N	0%
Race Track LR	2	12	640	123	19%	517	81%	0	0.0%	1.11	710	0.27	10	N	0%

SATURATION FLOWS	LANE NMBR	LANE WDTH	IDEAL STRTN FLOW	LANE FCTR Fw	TRCK FCTR Fhv	GRADE FCTR Fg	PRKNG FCTR Fp	BUS FCTR Fbb	AREA FCTR Fa	RGHT FCTR Frt	LEFT FCTR Flt	STRTN FLOW CLCTN
RT 1A NB SR	2	11	1800	0.97	0.983	1	1.00	1.00	1.0	0.99	1.00	3397
RT 1A SB S	2	11	1800	0.97	0.987	1	1.00	1.00	1.0	1.00	1.00	3447
RT 1A SB L	1	10	1800	0.93	1.000	1	1.00	1.00	1.0	1.00	1.00	1674
Race Track LR	2	12	1800	1.00	1.000	1	1.00	1.00	1.0	0.97	1.00	3496

CAPACITY ANALYSIS	ADJ FLOW	ADJ SAT	V/S	G/C	CPCTY C	V/C	CRTCL LANE
RT 1A NB SR	2082	3397	0.61	0.62	2106	0.99	Y
RT 1A SB S	1199	3446	0.35	0.62	2137	0.56	
RT 1A SB L	4	1674	0.00	0.62	1038	0.00	
Race Track LR	710	3496	0.20	0.27	944	0.75	Y

Cycle Length (sec): 90 Summation V/S: 0.82
Lost Time (sec): 8 V/C Critical: 0.90

VEHICLE DELAY	V/C	G/C	CYCLE LENGTH	DELAY ONE	CPCTY	DELAY TWO	PF	TOTAL DELAY	LOS
RT 1A NB SR	0.98	0.62	90	12.7	2106	12.8	1	25.5	D
RT 1A SB S	0.56	0.62	90	7.57	2137	0.25	1	7.83	B
RT 1A SB L	0.00	0.62	90	4.95	1038	0.00	1	4.95	B
Race Track LR	0.75	0.27	90	22.8	944	2.40	1	25.2	B

INTERSECTION SERVICE LEVEL DELAY: 20.1 C

LEFT TURN ADJUSTMENT FACTOR

Project 319, FJH 28 Mar 88

INPUT VARIABLES	EB	WB	SB	NB
Cycle length C(secs)			90	
Effctv Green G(secs)			26	
Lane Number N			1	
Ttl Approach Flow Rt Va			4	
Mainline Flow Rate Vm			0	
Left-turn Flow Rate Vlt			4	
Proportion of Left Plt			1	
Opposing lane number No			2	
Opposing flow rate Vo			2082	
Proportion lft oppsng flw Plto			0	

COMPUTATIONS

Sop	3600
Yo	0.58
Gu	-61.78
Fs	-0.43
Pl	1.00
Gq	87.78
Pt	0.00
Gf	0.00
El	-2.64
Fm	1.05
Flt	1.05

ROUTE 1A NB RT 1A SB

RACE TRACK WB

SIGNALIZED INTERSECTION ANALYSIS

MWRA Deer Island WWTP

REVERE AND OCEAN - AM PEAK FUTURE CONDITION, AUTOMOBILES MOVE WB LT

Project 319, FJH 28 Mar 88

LANE GROUPS	LANE NMBR	LANE WDTH	APPRCH VOLUME	RIGHT NO	RIGHT %	LEFT NO	LEFT %	TRUCKS NO	TRUCKS %	PEAK FCTR	ADJSTD VOLUME	G/C RATIO	PEDS /HR	PRKNG ALLWD	GRADE
Revere WB SL	3	12	1044	0	0%	804	77%	5	0.5%	1.16	1211	0.45	10	Y	0%
Revere EB R	2	9	207	207	100%	0	0%	4	1.9%	1.27	263	0.45	10	Y	0%
Ocean NB L	1	12	58	0	0%	58	100%	4	6.9%	1.44	84	0.45	10	Y	0%

SATURATION FLOWS	LANE NMBR	LANE WDTH	IDEAL STRTN FLOW	LANE FCTR Fw	TRCK FCTR Fhv	GRADE FCTR Fg	PRKNG FCTR Fp	BUS FCTR Fbb	AREA FCTR Fa	RGHT FCTR Frt	LEFT FCTR Flt	STRTN FLOW CLCTN
Revere WB SL	3	12	1800	1.00	0.998	1	1.00	1.00	1.0	1.00	1.00	5389
Revere EB R	2	9	1800	0.90	0.991	1	1.00	1.00	1.0	0.85	1.00	2729
Ocean NB L	1	12	1800	1.00	0.965	1	1.00	1.00	1.0	1.00	1.00	1737

CAPACITY ANALYSIS	ADJ FLOW	ADJ SAT	V/S	G/C	CPCTY C	V/C	CRTCL LANE
Revere WB SL	1211	5389	0.22	0.45	2425	0.50	Y
Revere EB R	263	2729	0.10	0.45	1228	0.21	
Ocean NB L	84	1737	0.05	0.45	782	0.11	Y

Cycle Length (sec): 80   Summation V/S: 0.27
Lost Time (sec): 8   V/C Critical: 0.30

VEHICLE DELAY	V/C	G/C	CYCLE LENGTH	DELAY ONE	CPCTY	DELAY TWO	PF	TOTAL DELAY	LOS
Revere WB SL	0.49	0.45	80	11.8	2425	0.14	1	12.0	B
Revere EB R	0.21	0.45	80	10.1	1228	0.01	1	10.1	B
Ocean NB L	0.10	0.45	80	9.66	782	0.00	1	9.66	B
INTERSECTION SERVICE LEVEL DELAY:								11.5	B

LEFT TURN ADJUSTMENT FACTOR

INPUT VARIABLES	EB	WB	NB	SB
Cycle length C(secs)				
Effctv Green G(secs)				
Lane Number N				
Ttl Approach Flow Rt Va				
Mainline Flow Rate Vm				
Left-turn Flow Rate Vlt				
Proportion of Left Plt				
Opposing lane number No				
Opposing flow rate Vo				
Proportion lft oppsng flw Plto				

COMPUTATIONS

Sop
Yo
Gu
Fs
Pl
Gq
Pt
Gf
El
6 Fm
Flt

REVERE EB   REVERE WB

OCEAN NB

SIGNALIZED INTERSECTION ANALYSIS

MWRA Deer Island WWTP

OCEAN AND BEACH - AM PEAK FUTURE CONDITION, AUTOMOBILES MOVE EB LT

LANE GROUPS	LANE NMBR	LANE WDTH	APPRCH VOLUME	RIGHT NO	RIGHT %	LEFT NO	LEFT %	TRUCKS NO	TRUCKS %	PEAK FCTR	ADJSTD VOLUME	G/C RATIO	PEDS /HR	PRKNG ALLWD	GRADE
Ocean NB SL	2	10	60	0	0%	20	33%	1	2.0%	1.11	67	0.48	10	Y	0%
Ocean SB SR	2	10	850	140	16%	0	0%	17	2.0%	1.11	944	0.48	10	Y	0%
Beach EB RL	1	15	370	40	11%	330	89%	2	0.5%	1.11	411	0.42	10	Y	0%
Beach WB SRL	2	10	50	0	0%	0	0%	1	2.0%	1.11	56	0.42	10	N	0%

SATURATION FLOWS	LANE NMBR	LANE WDTH	IDEAL STRTN FLOW	LANE FCTR Fw	TRCK FCTR Fhv	GRADE FCTR Fg	PRKNG FCTR Fp	BUS FCTR Fbb	AREA FCTR Fa	RGHT FCTR Frt	LEFT FCTR Flt	STRTN FLOW CLCTN
Ocean NB SL	2	10	1800	0.93	0.990	1	0.90	1.000	1.0	1.00	0.19	552
Ocean SB SR	2	10	1800	0.93	0.990	1	0.90	1.000	1.0	0.88	1.00	2616
Beach EB RL	1	15	1800	1.10	0.990	1	0.90	1.000	1.0	0.88	0.85	1329
Beach WB SRL	2	10	1800	0.93	0.990	1	0.90	1.000	1.0	0.90	1.00	2685

CAPACITY ANALYSIS	ADJ FLOW	ADJ SAT	V/S	G/C	CPCTY C	V/C	CRTCL LANE
Ocean NB SL	67	552.	0.12	0.48	265	0.25	
Ocean SB SR	944	2616	0.36	0.48	1256	0.75	Y
Beach EB RL	411	1329	0.31	0.42	558	0.74	Y
Beach WB SRL	56	2685	0.02	0.42	1128	0.05	

Cycle Length (sec): 85 Summation V/S: 0.67
Lost Time (sec): 8 V/C Critical: 0.74

INTERSECTION DELAY	V/C	G/C	CYCLE LENGTH	DELAY ONE	CPCTY	DELAY TWO	PF	TOTAL DELAY	LOS
Ocean NB SL	0.25	0.48	85	9.93	265	0.10	1	10.0	B
Ocean SB SR	0.75	0.48	85	13.6	1256	1.81	1	15.4	C
Beach EB RL	0.73	0.42	85	15.7	558	3.49	1	19.2	C
Beach WB SRL	0.04	0.42	85	11.0	1128	0.00	1	11.0	B

INTERSECTION SERVICE LEVEL DELAY: 16.1 C

LEFT TURN ADJUSTMENT FACTOR

Project 319, FJH 28 Mar 88

INPUT VARIABLES	NB	SB	EB	WB
Cycle length C(secs)	85		85	
Effctv Green G(secs)	41		36	
Lane Number N	1		1	
Ttl Approach Flow Rt Va	60		370	
Mainline Flow Rate Vm	40		40	
Left-turn Flow Rate Vlt	20		330	
Proportion of Left Plt	0.33		0.89	
Opposing lane number No	1		1	
Opposing flow rate Vo	850		50	
Proportion lft oppsng flw Plto	0.00		0.00	

COMPUTATIONS

	NB	SB	EB	WB
Sop	1800.00		1800.00	
Yo	0.47		0.03	
Gu	1.63		34.60	
Fs	0.34		0.84	
Pl	0.33		0.89	
Gq	39.37		1.40	
Pt	0.67		0.11	
Gf	4.00		0.19	
El	3.27		1.33	
Fm	0.19		0.85	
Flt	0.19		0.85	

VETERANS

V1 LT SB
V2 TH SB
V3 RT SB

SHIRLEY

V7 LT EB
V8 TH EB
V9 RT EB

V10 LT WB
V11 TH WB
V12 RT WB

V4 LT NB
V5 TH NB
V6 RT NB

SIGNALIZED INTERSECTION ANALYSIS

MWRA Deer Island WWTF

BENNINGTON AND SARATOGA -FUTURE CONDITION, AUTOMOBILES MOVE WB LEFT.

LANE GROUPS	LANE NMBR	LANE WDTH	APPRCH VOLUME	RIGHT NO	RIGHT %	LEFT NO	LEFT %	TRUCKS NO	TRUCKS %	PEAK FCTR	ADJSTD VOLUME	G/C RATIO	PEDS /HR	PRKNG ALLWD	GRADE
Bennington SB L	1	13	103	0	0%	103	100%	1	1.0%	1.02	105	0.29	0	Y	0%
Bennington SB SR	1	13	193	41	21%	0	0%	9	4.7%	1.02	197	0.29	0	Y	0%
Bennington NB SRL	2	13	666	332	50%	27	4%	8	1.2%	1.10	733	0.29	0	Y	0%
Bennington NB R	1	13	332	332	100%	0	0%	14	4.2%	1.10	365	0.42	0	Y	0%
Saratoga WB L prtctd	1	11	190	0	0%	190	100%	1	0.5%	1.08	205	0.39	0	N	0%
Saratoga WB L prmttd	1	11	190	0	0%	190	100%	1	0.5%	1.08	205	0.26	0	N	0%
Saratoga WB SR	1	11	345	151	44%	0	0%	9	2.6%	1.08	373	0.65	0	N	0%
Saratoga EB SRL	2	10	335	12	4%	40	12%	0	0.0%	1.13	379	0.23	0	Y	0%

SATURATION FLOWS	LANE NMBR	LANE WDTH	IDEAL STRTN FLOW	LANE FCTR Fw	TRCK FCTR Fhv	GRADE FCTR Fg	PRKNG FCTR Fp	BUS FCTR Fbb	AREA FCTR Fa	RGHT FCTR Frt	LEFT FCTR Flt	STRTN FLOW CLCTN
Bennington SB L	1	13	1800	1.03	0.995	1	0.90	1.000	1.00	1.00	0.57	939
Bennington SB SR	1	13	1800	1.03	0.970	1	0.90	1.000	1.00	0.97	1.00	1567
Bennington NB SRL	2	13	1800	1.03	0.988	1	0.90	1.000	1.00	0.93	1.00	3051
Bennington NB R	1	13	1800	1.03	0.980	1	0.90	1.000	1.00	0.85	1.00	1390
Saratoga WB L prtctd	1	11	1800	0.97	0.995	1	1.00	1.000	1.00	1.00	0.59	1027
Saratoga WB L prmttd	1	11	1800	0.97	0.995	1	1.00	1.000	1.00	1.00	0.59	1025
Saratoga WB SR	1	11	1800	0.97	0.990	1	1.00	1.000	1.00	0.93	1.00	1615
Saratoga EB SRL	2	10	1800	0.93	1.000	1	0.90	1.000	1.00	0.99	0.96	2890

CAPACITY ANALYSIS	ADJ FLOW	ADJ SAT	V/S	G/C	CPCTY C	V/C	CRTCL LANE
Bennington SB L	105	939	0.11	0.29	272	0.39	
Bennington SB SR	197	1567	0.13	0.29	454	0.43	
Bennington NB SRL	733	3051	0.24	0.29	885	0.83	
Bennington NB R	365	1390	0.26	0.42	584	0.63	Y
Saratoga WB L prtctd	205	1027	0.20	0.39	400	0.51	
Saratoga WB L prmttd	205	1025	0.20	0.26	266	0.77	
Saratoga WB SR	373	1615	0.23	0.65	1050	0.35	Y
Saratoga EB SRL	379	2890	0.13	0.23	665	0.57	Y

Cycle Length (sec): 111 Summation V/S: 0.62
Lost Time (sec): 2 V/C Critical: 0.64

INTERSECTION DELAY	V/C	G/C	CYCLE LENGTH	DELAY ONE	CPCTY	DELAY TWO	PF	TOTAL DELAY	LOS
Bennington SB L	0.38	0.29	111	23.9	272	0.46	1	24.4	C
Bennington SB SR	0.43	0.29	111	24.3	454	0.43	1	24.7	C
Bennington NB SRL	0.82	0.29	111	27.9	885	4.64	1	32.6	D
Bennington NB R	0.62	0.42	111	19.2	584	1.50	1	20.7	C
Saratoga WB L prtctd	0.51	0.39	111	19.6	400	0.93	1	20.5	C
Saratoga WB L prmttd	0.76	0.26	111	28.8	266	8.70	1	37.5	D
Saratoga WB SR	0.35	0.65	111	6.71	1050	0.09	1	6.80	B
Saratoga EB SRL	0.56	0.23	111	28.7	665	0.87	1	29.6	D

INTERSECTION SERVICE LEVEL DELAY: 24.3 C

LEFT TURN ADJUSTMENT FACTOR

Project 319, FJH 03 Mar 87

INPUT VARIABLES	NB	SB	EB	WB
Cycle length C(secs)	111	111	111	111
Effctv Green G(secs)	32	32	25	29
Lane Number N	2	1	2	1
Ttl Approach Flow Rt Va	666	103	335	190
Mainline Flow Rate Vm	639	0	295	0
Left-turn Flow Rate Vlt	27	103	40	190
Proportion of Left Plt	0.04	1.00	0.12	1.00
Opposing lane number No	2	2	2	2
Opposing flow rate Vo	193	334	192	295
Proportion lft oppsng flw Plto	0.00	0.04	0.00	0.12

COMPUTATIONS

	NB	SB	EB	WB
Sop	3600.00	3559.32	3600.00	3481.24
Yo	0.05	0.09	0.05	0.08
Gu	27.52	23.82	20.15	21.41
Fs	0.75	0.67	0.76	0.69
Pl	0.09	1.00	0.27	1.00
Gq	4.48	8.18	4.85	7.59
Pt	0.91	0.00	0.73	0.00
Gf	3.83	0.00	2.88	0.00
El	1.49	1.69	1.49	1.63
Fm	1.01	0.57	0.93	0.59
Flt	1.01	0.57	0.96	0.59

BENNINGTON SB

SARATOGA EB

Secondary Treatment Facilities Plan

Volume III

Appendix L
Flows & Loads

APPENDIX L

FLOWS AND LOADS

A breakdown of the flows by headworks for the North System -- Chelsea Creek, Columbus Park, Ward Street, and Winthrop Terminal -- and the South System flows from Nut Island, are presented in the following Tables L-1 through L-10. Flows are given in ten-year increments from 1990 to the design year 2020 for both low and high groundwater conditions. Average day wastewater flows are broken down into domestic flows and major and minor non-domestic flows. Minimum day, maximum day, and peak hour wastewater flows were calculated by applying appropriate peaking factors to the average flow. To these wastewater flows, average and maximum infiltration/inflow were added. Total flow with storm was taken to be the capacity of each of the headworks for maximum day and peak hour flow.

Annual average biochemical oxygen demand (BOD) and total suspended solids (TSS) loadings have also been segregated by North and South systems based on the 1986 Fall sampling program, and are presented in Tables L-11 through L-13. Data for 1986 and from 1990 to 2020 in ten-year increments are given. Maximum day, maximum 15-day, and maximum 30-day loadings shown were calculated using appropriate peaking factors.

Storm loadings were obtained by assuming an additional 165,000 lbs/day BOD loading and 400,000 lbs/day TSS loading attributed to the storm flow.

For more information on flows and loadings refer to Section 6.0 of this Volume and Section 8.0 of Volume II, Facilities Planning Background.

TABLE L-1

FLOWS AT CHELSEA CREEK HEADWORKS
LOW GROUNDWATER CONDITIONS

	1990				2000				2010				2020			
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		37				39				38				38		
NON DOMESTIC																
MAJOR USERS		10				10				10				10		
MINOR USERS		10				11				12				14		
SUBTOTAL	39	57	83	119	41	60	85	125	41	60	85	125	44	63	89	131
INFILTRATION AND INFLOW	57	57	71	71	57	57	71	71	57	57	71	71	57	57	71	71
TOTAL	96	114	154	190	98	117	156	196	98	117	156	196	101	120	161	202
TOTAL WITH STORM FLOW			350	350			350	350			350	350			350	350

Note: 350 mgd maximum capacity

TABLE L-2

FLOWS AT CHELSEA CREEK HEADWORKS
HIGH GROUNDWATER CONDITIONS

	1990				2000				2010				2020			
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		37				39				38				39		
NON DOMESTIC																
MAJOR USERS		10				10				10				10		
MINOR USERS		10				11				12				14		
SUBTOTAL	39	57	83	119	41	60	85	125	41	60	85	125	44	63	89	131
INFILTRATION AND INFLOW	129	129	176	176	129	129	176	176	129	129	176	176	129	129	176	176
TOTAL	168	186	258	295	170	189	261	300	170	189	261	300	173	192	265	307
TOTAL WITH STORM FLOW			350	350			350	350			350	350			350	350

Note: 350 mgd maximum capacity

TABLE L-3

FLOWS AT COLUMBUS PARK HEADWORKS
LOW GROUNDWATER CONDITIONS

	1990				2000				2010				2020			
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		14				14				14				15		
NON DOMESTIC																
MAJOR USERS		10				10				10				10		
MINOR USERS		10				11				11				12		
SUBTOTAL	22	34	51	75	23	35	53	77	23	35	53	77	24	37	55	81
INFILTRATION AND INFLOW	21	21	27	27	21	21	27	27	21	21	27	27	21	21	27	27
TOTAL	44	55	78	102	44	56	79	104	44	56	79	104	46	58	82	108
TOTAL WITH STORM FLOW			182	182			182	182			182	182			182	182

Note: 182 mgd maximum capacity

TABLE L-4

FLOWS AT COLUMBUS PARK HEADWORKS
HIGH GROUNDWATER CONDITIONS

	1990				2000				2010				2020			
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		14				14				14				15		
NON DOMESTIC																
MAJOR USERS		10				10				10				10		
MINOR USERS		10				11				11				12		
SUBTOTAL	22	34	51	75	23	35	53	77	23	35	53	77	24	37	55	81
INFILTRATION AND INFLOW	49	49	66	66	49	49	66	66	49	49	66	66	49	49	66	66
TOTAL	71	83	117	141	72	84	119	143	72	84	119	143	73	86	121	147
TOTAL WITH STORM FLOW			182	182			182	182			182	182			182	182

Note: 182 mgd maximum capacity

TABLE L-5

FLOWS AT WARD STREET HEADWORKS
LOW GROUNDWATER CONDITIONS

	1990				2000				2010				2020			
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		24				25				25				25		
NON DOMESTIC																
MAJOR USERS		9				9				9				9		
MINOR USERS		8				9				10				11		
SUBTOTAL	28	41	60	88	29	43	63	92	30	44	64	94	30	45	66	95
INFILTRATION AND INFLOW	43	43	54	54	43	43	54	54	43	43	54	54	43	43	54	54
TOTAL	71	84	114	142	72	86	117	146	73	87	118	147	73	88	119	149
TOTAL WITH STORM FLOW			256	256			256	256			256	256			256	256

Note: 256 mgd maximum capacity

TABLE L-6

FLOWS AT WARD STREET HEADWORKS
HIGH GROUNDWATER CONDITIONS

	1990				2000				2010				2020			
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		24				25				25				25		
NON DOMESTIC																
MAJOR USERS		9				9				9				9		
MINOR USERS		8				9				10				11		
SUBTOTAL	28	41	60	88	29	43	63	92	30	44	64	94	30	45	66	95
INFILTRATION AND INFLOW	97	97	133	133	97	97	133	133	97	97	133	133	97	97	133	133
TOTAL	125	138	193	221	126	140	195	225	127	141	197	226	128	142	198	228
TOTAL WITH STORM FLOW			256	256			256	256			256	256			256	256

Note: 256 mgd maximum capacity

TABLE L-7

FLOWS AT WINTHROP TERMINAL HEADWORKS
LOW GROUNDWATER CONDITIONS

	1990				2000				2010				2020			
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		4				5				5				6		
NON DOMESTIC																
MAJOR USERS		2				2				2				2		
MINOR USERS		1				1				1				1		
SUBTOTAL	4	7	13	19	4	8	14	22	4	8	14	22	5	9	15	24
INFILTRATION AND INFLOW	5	5	6	6	5	5	6	6	5	5	6	6	5	5	6	6
TOTAL	9	12	19	26	10	13	20	28	10	13	20	28	10	14	22	30
TOTAL WITH STORM FLOW			125	125			125	125			125	125			125	125

Note: 125 mgd maximum capacity

TABLE L-8

FLOWS AT WINTHROP TERMINAL HEADWORKS
HIGH GROUNDWATER CONDITIONS

	1990				2000				2010				2020			
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
DOMESTIC		4				5				5				6		
NON DOMESTIC																
MAJOR USERS		2				2				2				2		
MINOR USERS		1				1				1				1		
SUBTOTAL	4	7	9	11	4	8	14	22	4	8	14	22	5	9	15	24
INFILTRATION AND INFLOW	11	11	16	16	11	11	16	16	11	11	16	16	11	11	16	16
TOTAL	15	18	25	27	16	19	30	37	16	19	30	37	17	20	31	39
TOTAL WITH STORM FLOW			125	125			125	125			125	125			125	125

Note: 125 mgd maximum capacity

TABLE L-9

FLOWS AT NUT ISLAND TREATMENT FACILITY
LOW GROUNDWATER CONDITIONS

	1990				2000				2010				2020			
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hou (mgd)
DOMESTIC		48				50				50				51		
NON DOMESTIC																
MAJOR USERS		12				12				12				12		
MINOR USERS		18				18				20				22		
SUBTOTAL	54	78	109	148	56	80	112	152	57	82	115	156	59	85	120	170
INFILTRATION AND INFLOW	25	25	115	180	25	25	115	180	25	25	115	180	25	25	115	180
TOTAL	79	103	224	328	81	105	227	332	82	107	230	336	85	110	235	350
TRANSMISSION CAPACITY			360	360			360	360			360	360			360	360

Note: 360 mgd maximum hydraulic capacity of the South Metropolitan Sewer
*Before I/I reduction

TABLE L-10

FLOWS AT NUT ISLAND TREATMENT FACILITY
HIGH GROUNDWATER CONDITIONS

	1990				2000				2010				2020			
	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)	Min Day (mgd)	Avg Day (mgd)	Max Day (mgd)	Peak Hour (mgd)
OMESTIC		48				50				50				51		
ON DOMESTIC																
MAJOR USERS		12				12				12				12		
MINOR USERS		18				18				20				22		
UBTOTAL	54	78	109	148	56	80	112	152	57	82	115	156	59	85	120	170
NFILTRATION ND INFLOW	145	145	235	300	145	145	235	300	145	145	235	300	145	145	235	300*
OTAL	199	223	344	448	201	225	347	452	202	227	350	456	205	230	355	470
RANSMISSION APACITY			360	360			360	360			360	360			360	360

ote: 360 mgd maximum capacity of the South Metropolitan Sewer
Before I/I reduction

TABLE L-11

BOD LOADING BREAKDOWN
BY NORTH AND SOUTH SYSTEMS
(lb/day)

		North System	South System	Total
1986	Annual Ave	328,000	172,000	500,000
Max 1-day		655,000	345,000	1,000,000
	Max 3-day	491,000	259,000	750,000
	Max 15-day	458,000	242,000	700,000
	Max 30-day	426,000	224,000	650,000
1990	Annual Ave	331,000	174,000	505,000
	Max 1-day	662,000	348,000	1,010,000
	Max 3-day	496,000	262,000	758,000
	Max 15-day	463,000	244,000	707,000
	Max 30-day	430,000	226,000	656,000
2000	Annual Ave	352,000	185,000	537,000
	Max 1-day	703,000	371,000	1,074,000
	Max 3-day	528,000	277,000	805,000
	Max 15-day	492,000	259,000	751,000
	Max 30-day	457,000	241,000	698,000
2010	Annual Ave	363,000	191,000	554,000
	Max 1-day	726,000	382,000	1,108,000
	Max 3-day	544,000	287,000	831,000
	Max 15-day	508,000	267,000	775,000
	Max 30-day	472,000	248,000	720,000
2020	Annual Ave	373,000	197,000	570,000
	Max 1-day	747,000	393,000	1,140,000
	Max 3-day	560,000	295,000	855,000
	Max 15-day	523,000	275,000	798,000
	Max 30-day	485,000	256,000	741,000

TABLE L-12

TSS LOADING BREAKDOWN BY NORTH AND SOUTH SYSTEMS

(lb/day)

		North System	South System	Total
1986	Annual Ave	291,000	154,000	445,000
	Max 1-day	612,000	322,000	934,000
	Max 15-day	437,000	230,000	667,000
	Max 30-day	379,000	199,000	578,000
1990	Annual Ave	295,000	155,000	450,000
	Max 1-day	619,000	326,000	945,000
	Max 15-day	442,000	233,000	675,000
	Max 30-day	383,000	202,000	585,000
2000	Annual Ave	315,000	166,000	481,000
	Max 1-day	662,000	348,000	1,010,000
	Max 15-day	472,000	249,000	721,000
	Max 30-day	410,000	216,000	626,000
2010	Annual Ave	326,000	172,000	498,000
	Max 1-day	685,000	361,000	1,046,000
	Max 15-day	489,000	258,000	747,000
	Max 30-day	424,000	223,000	647,000
2020	Annual Ave	337,000	178,000	515,000
	Max 1-day	708,000	373,000	1,081,000
	Max 15-day	506,000	266,000	772,000
	Max 30-day	438,000	231,000	669,000

TABLE L-13

NORTH SYSTEM
STORM LOADINGS
(lb/day)

Year	BOD	TSS
1986	493,000	691,000
1990	496,000	695,000
2000	517,000	715,000
2010	528,000	726,000
2020	538,000	737,000

Secondary Treatment Facilities Plan

Volume III

Appendix M
Stacked Clarifiers

APPENDIX M

SECONDARY TREATMENT FACILITIES PLAN

SEDIMENTATION USING STACKED CLARIFIERS

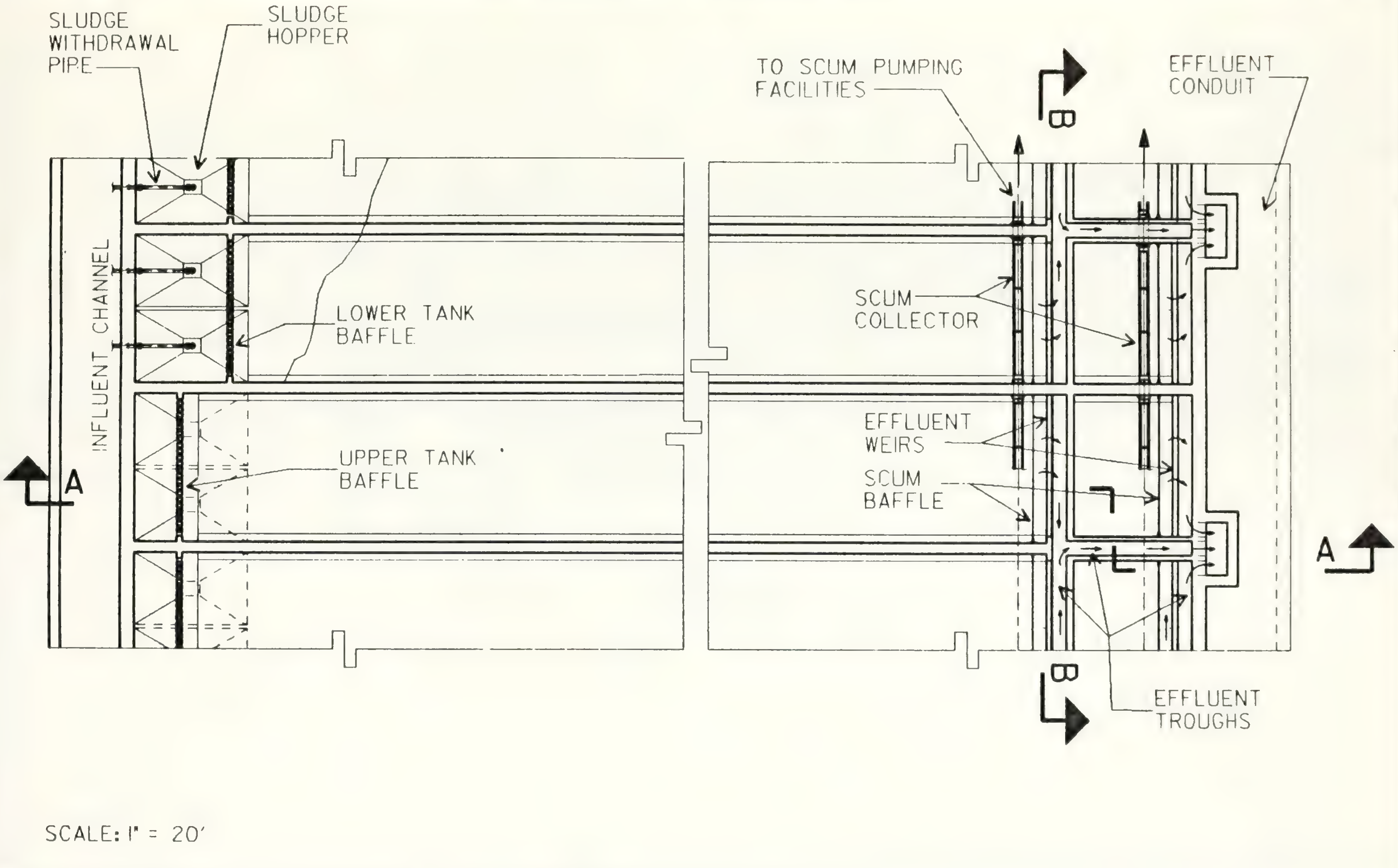
INTRODUCTION

New treatment facilities at Deer Island will include preliminary, primary and secondary treatment and disinfection. An integral part of primary and secondary treatment is the settling or sedimentation process which takes place in primary and secondary clarifiers. Various types and shapes of clarifiers were investigated during the screening of the unit processes for the Secondary Treatment Facilities Plan. The Report on Evaluation and Screening of Unit Processes, December 1986, identified conventional unstacked rectangular clarifiers and stacked rectangular clarifiers for further evaluation. Conventional rectangular clarifiers are a proven and effective means for settling solids and are more land-efficient than circular clarifiers. Stacked rectangular clarifiers were selected for further evaluation based on additional land area savings over conventional rectangular clarifiers.

Stacked rectangular clarifiers operate similarly to conventional rectangular clarifiers in terms of influent and effluent flow patterns and sludge collection and removal. The stacked clarifiers are actually two tanks, one above the other, operating on a common water surface. Each clarifier (tank) is fed independently, resulting in parallel flow through the upper and lower tanks. Settled solids are collected from each tank by chain and flight collectors discharging to a common hopper. The effluent from both the upper and lower tanks discharges to transverse weirs. The distinction between parallel-flow stacked clarifiers and series-flow trayed clarifiers is that the trayed clarifiers are arranged such that flow travels through one tank and then through the other tank. Trayed clarifiers have been used for sedimentation in water treatment facilities, but not in municipal wastewater treatment plants. The trayed clarifiers were not considered because of a lack of wastewater-related operating history, and because of the different settling characteristics of solids in water and in wastewater.

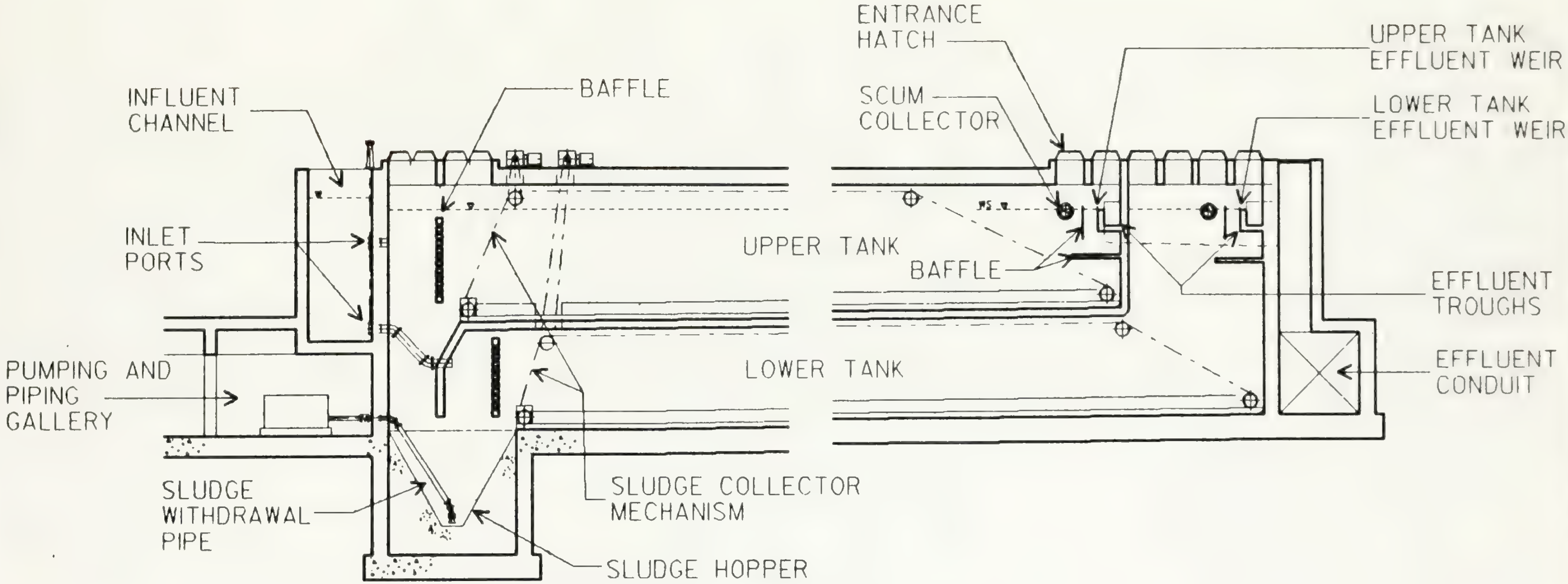
Preliminary layouts of the planned treatment plant on Deer Island included conventional rectangular primary and secondary clarifiers, stacked primary and secondary clarifiers, and a combination of the stacked primary and conventional secondary clarifiers. The layouts showed that the completely conventional layout alternative occupied nearly the entire island, required that all excavated material be transported off-site, infringed on buffering berms, limited open space, and infringed on potential historical and archaeological sites. The stacked primary and conventional secondary clarifiers layout alternative used almost the entire island as well, allowed for small visual buffering berms, and limited open space to the area nearest Point Shirley. The use of stacked primary and stacked secondary clarifiers most closely meets mitigation commitments and site planning goals.

Plan and section views of the stacked primary clarifiers proposed for use at Deer Island are shown in Figures M-1, M-2 and M-3. The secondary clarifiers are configured in much the same way, with the only significant difference being the double tranverse weirs provided for each



MASSACHUSETTS WATER RESOURCES AUTHORITY

FIGURE M-1
STACKED PRIMARY CLARIFIERS
PLAN VIEW

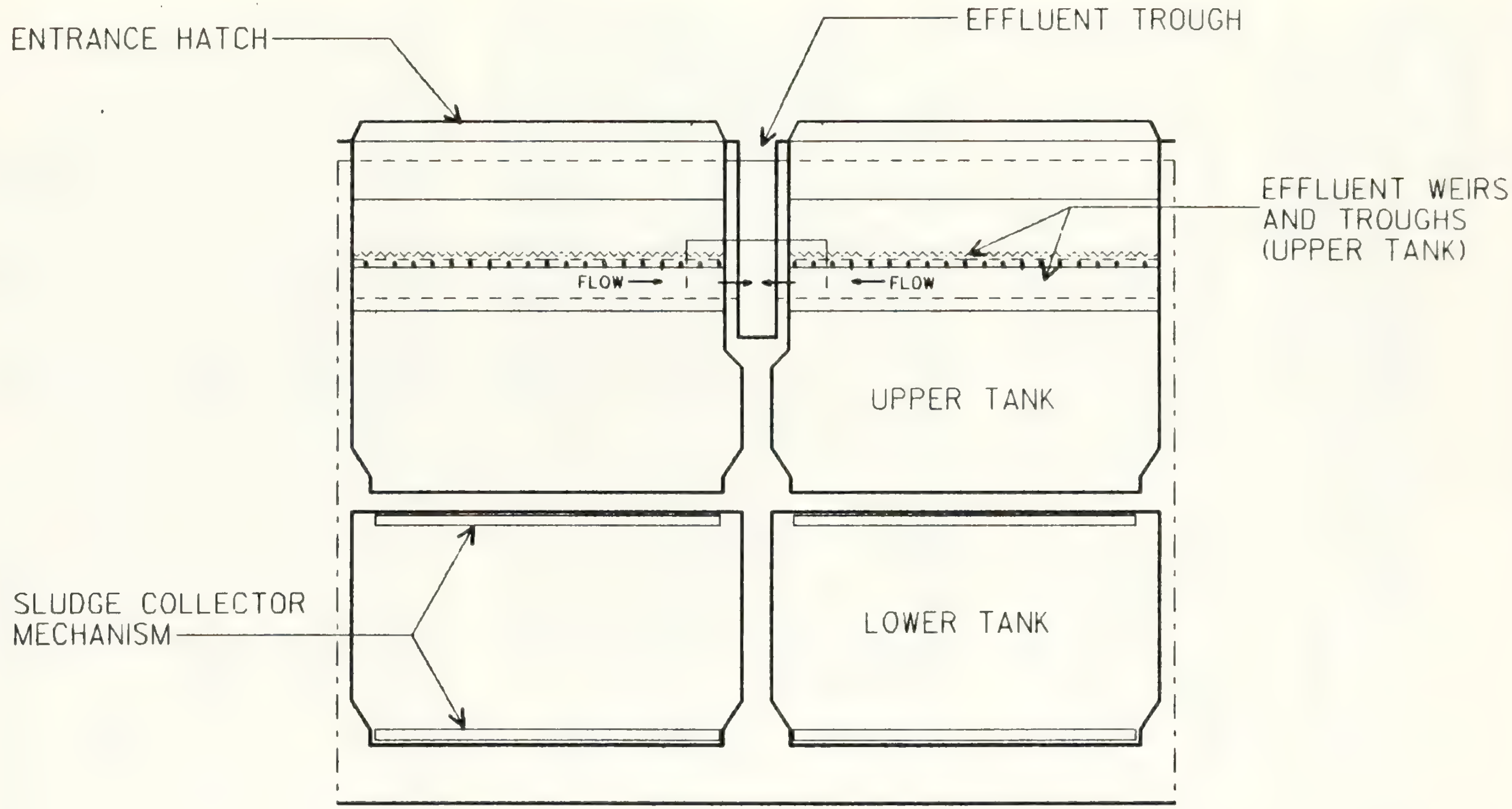


SECTION A-A

SCALE: 1" = 20'

MASSACHUSETTS WATER RESOURCES AUTHORITY

FIGURE M-2
STACKED PRIMARY CLARIFIERS
LONGITUDINAL SECTION



SECTION B-B

SCALE: 1" = 10'

MASSACHUSETTS WATER RESOURCES AUTHORITY

FIGURE M-3
STACKED PRIMARY CLAFIFIERS
CROSS SECTION

tank as shown in the section view in Figure M-4.

EXPERIENCE

Operating history for conventional rectangular clarifiers at large wastewater treatment plants in the United States has been successful for many years. Table M-1 presents the effluent TSS concentrations that are achieved by selected large treatment plants in the United States using conventional rectangular clarifiers.

Stacked rectangular clarifiers have been used effectively in Japan for primary and secondary wastewater sedimentation for over 13 years. Stacked units are currently being used in Japan at 37 municipal wastewater treatment plants ranging in design size from 16 mgd to 477 mgd. The average, peak, and design flows of the Japanese plants using primary or secondary stacked clarifiers having a peak flow capacity of over 100 mgd are presented in Tables M-2 and M-3. Clarifier operating data is also shown in these tables.

For the stacked primary clarifiers, the average design surface overflow rates range from 500 to 1200 gpd/ft^2. The side water depth of the clarifiers ranges from 7.9 to 12.5 ft. The average overflow rates for the stacked secondary clarifiers range from 360 to 860 gpd/ft^2 while the average solids loading rates range from 5.3 to 13.5 lb/d/ft^2. The sidewater depth of the secondary clarifiers ranges from 8.5 to 14.8 ft. The stacked secondary clarifiers have operated very successfully, as indicated by effluent BOD and TSS concentrations. For both parameters, the average effluent concentrations at each plant are less than 15 mg/l. The stacked clarifiers' effectiveness in removing solids is also shown in the graph of the average surface overflow rates versus effluent TSS in Figure M-5, and in the solids loading rate verses effluent TSS plot in Figure M-6. Comparison of the effluent TSS concentrations from the Japanese plants using stacked clarifiers to those of the United States plants using conventional clarifiers, in Figures M-5 and M-6, indicates that the stacked clarifiers perform as well as the conventional clarifiers. There is no apparent difference between the solids removal effectiveness of the stacked and unstacked clarifiers.

Japanese engineers have reported that scum has not caused operating problems at either the primary or secondary effluent weirs. However, scum has been known to accumulate on the ceiling of the lower clarifiers. Recent Japanese engineering designs have controlled this problem by using chain and flight collectors to pull the scum to the effluent end of the lower clarifier for removal. Oil and grease levels of the influent wastewater to the Japanese plants presented in Table M-4 may be used as an indicator of potential for scum formation. The grease and oil concentration that may be expected in the Deer Island influent, based on the sampling program developed for the Facilities Plan and historic operational data, is approximately 35 mg/l. This volume is in line with the grease and oil concentrations coming into the Japanese plants. Therefore, it is expected that the stacked clarifiers at Deer Island will also perform well. At Deer Island, scum entering the clarifiers will be scraped by chain and flight sludge collectors along the water surface of the upper tank and along the ceiling of the lower tank to the effluent end of the tanks. Scum will be collected and removed before it reaches the effluent weirs.

Table M-1

Conventional Rectangular Secondary Clarifier Operating Data

Plant	City	Ave Daily Flow[1] (MGD)	Ave. Aeration Tank MLSS (mg/l)	Ave. Solids Loading Rate[2] (lb/d/ft^2)	Ave. Oveflow Rate[3] (gpd/ft^2)	Annual Ave. Effluent BOD (mg/l)	Annual Ave. Effluent TSS (mg/l)	Clarifier Depths[4] (ft)	Clarifier Lengths[4] (ft)
Joint WPCP	Los Angeles	100	3000	25	550	12	12	14	167
Blue Plains-E	Washington D.C.	144	2460	13	633	11	19	12	260
Blue Plains-W	Washington D.C.	169	2700	18	797	18	35	11.7	241
Wards Island	New York	305	780	9	1080	8	13	13	176
								13	240
Tallman Island	New York	63	1200	9	780	7	9	12	189
								12	272

(1) Average Daily Flow To Secondary Treatment

(2) Average solids loading rates presented were obtained directly from the treatment plants or calculated based on the average daily flows, MLSS concentrations and clarifier surface areas obtained from the treatment plants.

(3) Average overflow rates presented were obtained directly from the treatment plants or calculated based on the average daily flows and clarifier surface areas obtained from the treatment plants.

(4) Additional clarifier lengths and depths are presented when the treatment plant has secondary clarifiers with different dimensions.

Ta M-2

Japanese Wastewater Treatment Plant
Operating Data For Primary Stacked Clarifiers

Plant	City	Daily Ave(MGD)	Flow Design Ave(MGD)	Flow Peak (MGD)	Design Overflow Rate (gpd/ft^2)	Clarifier Depth per Tray (ft) Upper	Clarifier Depth per Tray (ft) Lower	Clarifier Length per Tray (ft) Upper	Clarifier Length per Tray (ft) Lower
Mikawashima	Tokyo	213	251	376	500 to 1230	11.5	11.5		
Shibaura	Tokyo	356	420	630	500 to 1230	12.1 12.8	12.5 14.8	121 112	169 131
Morigasaki-E.	Tokyo	406	477	717	500 to 1230	9.8 12.1	9.8 12.1	114 114	131 131
Shingashi	Tokyo	312	367	550	500 to 1230	12.8	11.1	123	149
Kosuge	Tokyo	101	119	178	500 to 1230	7.9	7.9	NA	NA
Shibata	Nagoya	50	67	101	1030	9.8	9.8	NA	NA
Uchide	Nagoya	55	74	111	1230				
Toba	Kyoto	250	323	461	980	10.2	10.2	NA	NA
Higashinada	Kobe	69	92	181	610	11.5	11.5	NA	NA
Hiakari	Kitakyushu	76	96	143	740	12.1	12.1	NA	NA

(1) Design overflow rates were obtained directly from Japanese engineers.
(2) The abbreviation NA indicates that the information is not available.

Table M-3

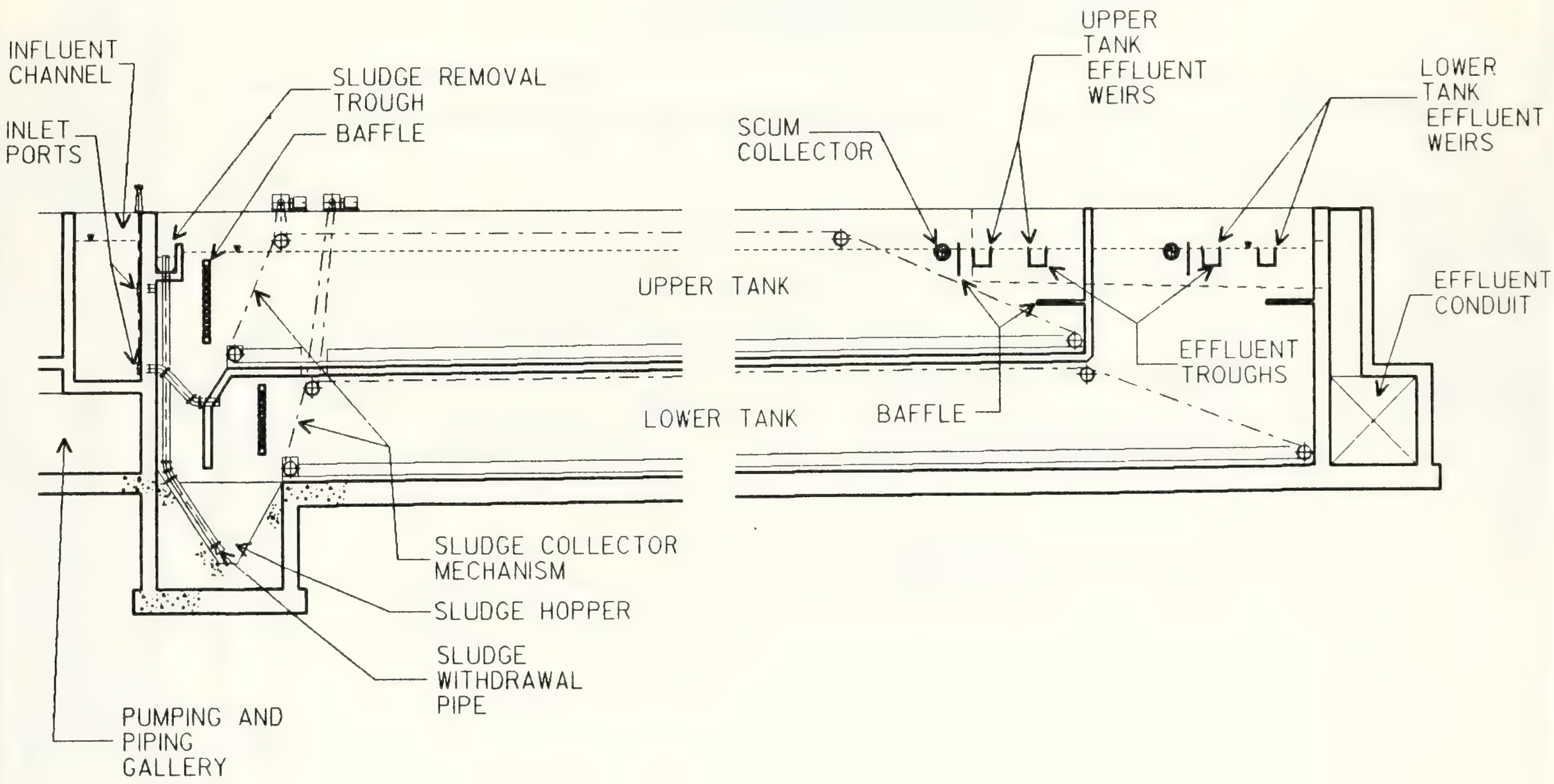
Japanese Wastewater Treatment Plant
Operating Data For Secondary Stacked Clarifiers

Plant	City	Flow Daily Ave(MGD)	Flow Design (MGD)	Flow Peak (MGD)	Design Aeration Tank MLSS (mg/l)	Ave Solids Loading Rate[1] ($lb/d/ft^2$)	Overflow Rate[1] Ave (gpd/ft^2)	Overflow Rate[1] Peak (gpd/ft^2)	Effluent BOD (mg/l)	Effluent TSS (mg/l)	Clarifier Depths per Tray (ft) Upper	Clarifier Depths per Tray (ft) Lower	Clarifier Lengths per Tray[2] (ft) Upper	Clarifier Lengths per Tray[2] (ft) Lower
Mikawashima	Tokyo	213	251	376	1700	13.5	830	1460	6	6	11.5	11.5	148	134
Shibaura	Tokyo	356	420	630	2690	8.4	590	1050	7	7	14.8	14.8	117 131	117 131
Ochiai	Tokyo	133	156	234	2650	5.9	860	1520	12	14	8.9	9.2	134	145
Morigasaki-E.	Tokyo	406	477	717	2620	5.7	430	770	3	3	9.5	8.5	180	180
Shingashi	Tokyo	312	367	550	2490	10.8	750	1320	5	5	12.8	10.5	109	161
Kosuge	Tokyo	101	119	178	2670	8.8	610	1070	4	5	11.5	11.2	NA	NA
Kasai	Tokyo	211	248	372	2000	5.3	360	630	2	4	9.8	9.8	NA	NA
Shibata	Nagoya	50	67	101	NA	6.2	480	960	14	8	9.8	9.8	NA	NA
Uchide	Nagoya	55	74	111	NA	10.5	500	1020	7	6	11.5	11.5	NA	NA
Toba	Kyoto	250	323	461	2150	5.3	510	940	9	6	10.2	10.2	NA	NA
Higashinada	Kobe	69	92	181	2200	5.8	470	1220	11	12	10.8	10.8	NA	NA
Hiakari	Kitakyushu	76	96	143	1740	10.7	560	1060	5	4	10.2	10.2	NA	NA

(1) Average solids loading and surface overflow rates were obtained directly from Japanese engineers.

(2) Additional clarifier lengths and depths are presented when the treatment plant has secondary clarifiers with different dimensions.

(3) The abbreviation NA indicates that the information is not available.



SCALE: 1" = 20'

MASSACHUSETTS
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AUTHORITY

FIGURE M-4
STACKED SECONDARY CLARIFIERS
LONGITUDINAL SECTION

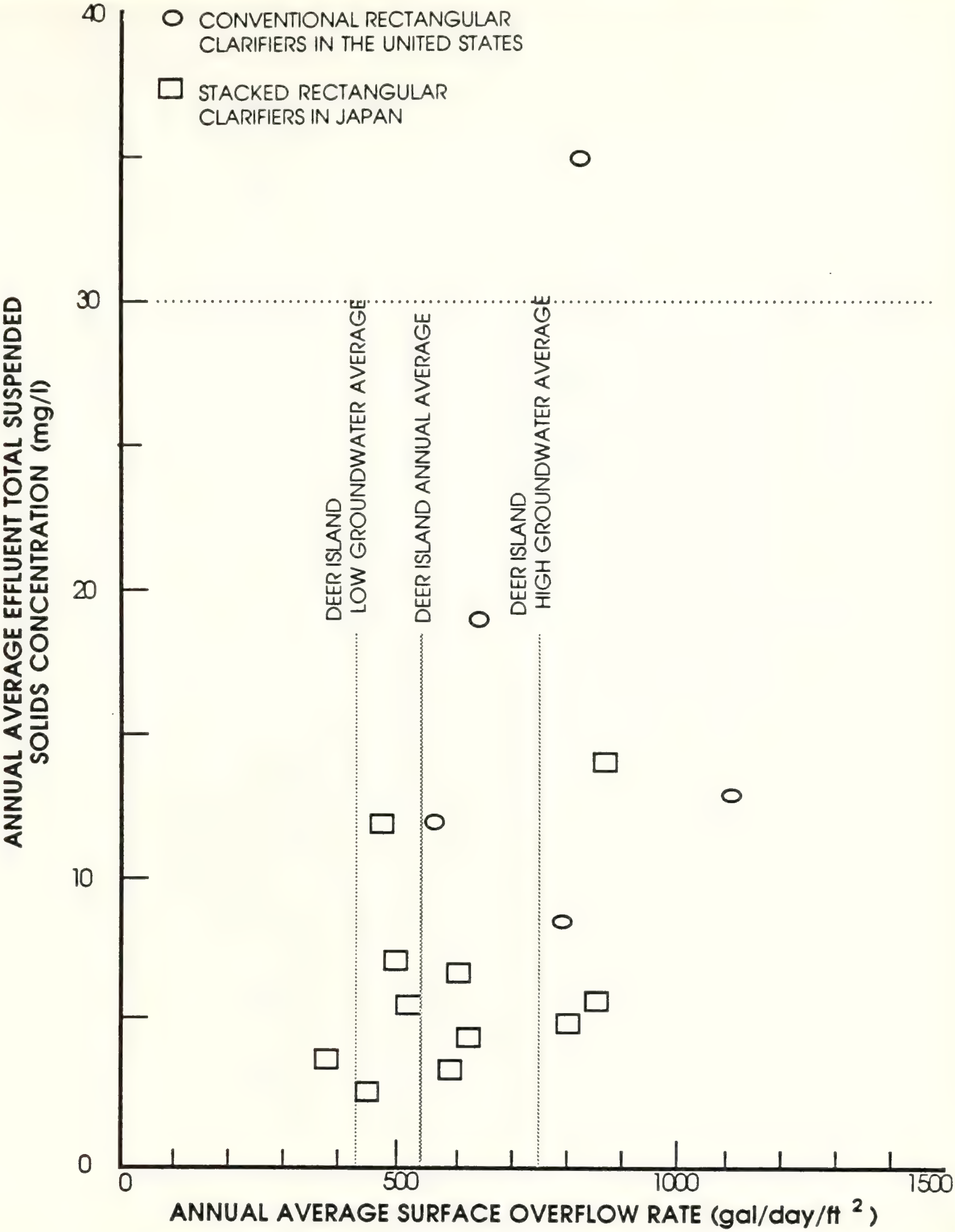

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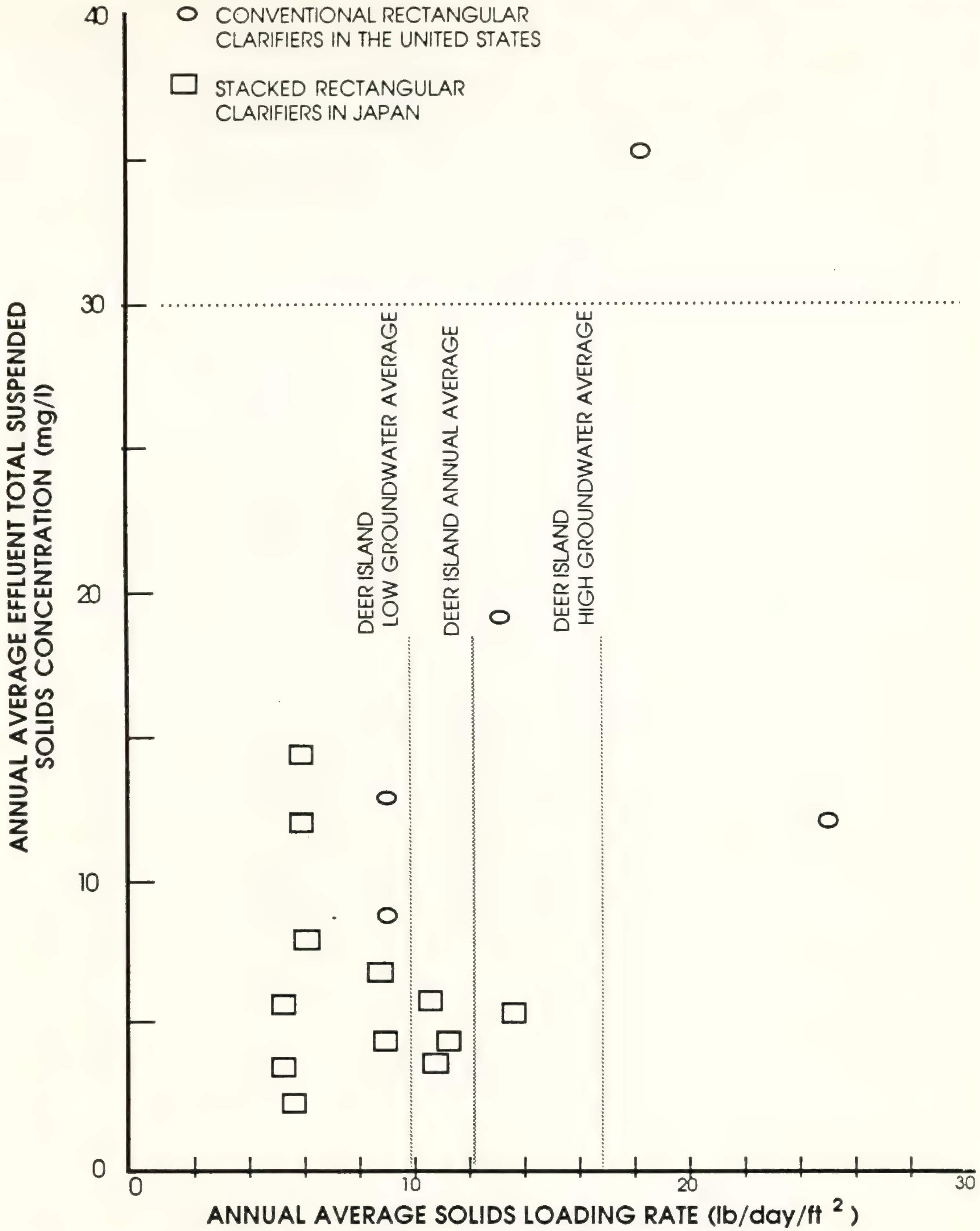
FIGURE M-5
RECTANGULAR SECONDARY CLARIFIERS - SURFACE OVERFLOW RATE VS. EFFLUENT TOTAL SUSPENDED SOLIDS



MASSACHUSETTS WATER RESOURCES AUTHORITY

FIGURE M-6
RECTANGULAR SECONDARY CLARIFIERS - SOLIDS LOADING RATE VS. EFFLUENT TOTAL SUSPENDED SOLIDS

Table M-4

Influent Grease and Oil Concentrations at Japanese Wastewater Treatment Plants

Plant	City	Ave Daily Flow (MGD)	Oil and Grease Content (mg/l)
Mikawashima	Tokyo	213	12.2
Shibaura	Tokyo	356	11.0
Ochiai	Tokyo	133	13.5
Morigasaki	Tokyo	406	8.0
Shingashi	Tokyo	312	24.8
Toba	Kyoto	250	3.0
Higashinada	Kobe	69	45.5
Seibu	Kobe	38	32.5
Hiakari	Kitakyushu	76	122.0
			Ave. = 30.3

STACKED RECTANGULAR CLARIFIERS FOR DEER ISLAND

Primary Clarifiers

For new primary treatment facilities at Deer Island, the stacked parallel flow clarifiers were sized based on a peak surface overflow rate of 2000 gpd/ft^2 for each clarifier. At peak flow of 1270 mgd, 190 mgd passes through fine screens instead of receiving secondary treatment. The flow that passes through the screens is taken from one battery whose overflow rate is maintained at the average daily rate of 1200 gpd/ft^2. The overflow rate in the remaining three batteries is 2300 gpd/ft^2. During the time period when the new primary treatment facilities are operating and the secondary treatment facilities are under construction, all of the primary batteries will be loaded equally. The peak overflow rate is well within the 3000 gpd/ft^2 guideline presented in TR-16 and the EPA Design Manual. The minimum depth of the primary clarifiers is 12 ft, which is within the range of the depths of the Japanese stacked clarifiers as reported in Table M-2. The depth also conforms to the guidelines set by TR-16 and the Ten States Standards.

Secondary Clarifiers

Planning of the stacked secondary clarifiers at Deer Island is based on existing design standards, current engineering practice, operational experience in Japan, and discussions with MWRA review consultants. The high groundwater average overflow rate of 750 gpd/ft^2 for the activated sludge system clarifiers is within the 400 to 800 gpd/ft^2 guideline range established by TR-16 and the EPA Design Manual, and the 800 gpd/ft^2 guideline of MOP8. The peak overflow rate of 1200 gpd/ft^2 meets TR-16 and Ten States Standards Guidelines. The Deer Island high groundwater average overflow rate is also within the range of the average overflow rates at the Japanese plants. Figure M-5 suggests that for the high groundwater average overflow rate used to size the secondary clarifiers on Deer Island, effluent suspended solids concentrations below 15 mg/l could be expected.

The minimum 13-ft side water depth of the secondary clarifiers is within the guideline range of the above mentioned publications, and between the maximum and minimum depths of the listed Japanese plants.

The solids loading rate for the Deer Island secondary clarifiers at the high groundwater average daily flow of 670 mgd is 16.6 $lb/d/ft^2$, 9.7 $lb/d/ft^2$ at the 390 mgd low groundwater average daily flow, and 12.0 $lb/d/ft^2$ at the annual average flow of 480 mgd. The annual average solids loading rates of the Japanese plants are somewhat lower than the average rates of the Deer Island secondaries. This does not appear to be a problem, but solids loadings should be confirmed through pilot studies.

In addition to providing effective primary and secondary settling, the proposed stacked clarifier configuration used for this project has certain advantages over conventional rectangular clarifiers and other stacked configurations. For stacked primary clarifiers, sludge piping and pumping equipment requirements are approximately one half of that for conventional units. For secondary sludge removal, piping and valving costs are also reduced.

Also, the overall manageability of a treatment plant is improved as the size of the plant footprint is reduced.

When developing the layout of the stacked clarifiers for Deer Island, the design drawings of five Japanese stacked clarifiers were reviewed. The clarifier designs were similar, yet offered different features. The design features of the Japanese clarifiers that are best suited to the Deer Island primary and secondary clarifiers have been adopted. The proposed method for introducing flow to each Deer Island primary and secondary clarifier directs the flow from an influent channel through two inlet ports to the upper tank, and through two pipes to the lower tank. The flow to the lower tank is piped past the sludge hoppers to the head of the lower tank to prevent the influent flow from interfering with the settling of upper tank solids to the sludge hoppers.

The configuration of transverse weirs for the upper and lower clarifiers for both the primary and secondary clarifiers at Deer Island allows for removal of scum from both the upper and lower clarifiers before the flow passes over the effluent weirs. Another benefit of this tank arrangement is direct access to the lower tank in the vicinity of the effluent weirs. Entrance is not as easily attainable for tank geometries using longitudinal effluent weirs along the sides of the tanks. The recommended clarifier arrangement also has full top-to-bottom wall construction between adjacent tanks. Data from Okuno and Fukuda showed that stacked clarifier designs similar to the recommended arrangement for Deer Island have longer actual retention times, higher volumetric efficiencies (less dead space), and are less likely to short circuit than stacked clarifiers having partial wall construction and longitudinal effluent weirs extending closer to the influent openings. The full top-to-bottom wall construction also allows for isolation of just the upper and lower tanks of a stacked set when taking one tank out of service. In essence, only the surface area of two tanks is lost in order to take one tank out of service. For the stacked clarifiers not using full wall construction, and conventional rectangular clarifiers having widths greater than 40 ft, if one tank must be isolated, greater surface area is taken out of service.

COST COMPARISON OF STACKED SECONDARY CLARIFIERS AND CONVENTIONAL SECONDARY CLARIFIERS

Comparison between the costs of stacked and conventional secondary clarifiers indicates that the stacked clarifiers have a present worth value of $153 million, while conventional units have a present worth value of $142 million. A summary of the life cycle costs of the secondary clarifiers is presented in Table M-5. Construction costs cover materials, excavation, backfilling, dewatering, and inter-process influent and effluent channels. Equipment costs include sludge collectors, sludge pumps and piping, instrumentation, HVAC, plumbing, and electrical equipment.

The operation and maintenance costs would be essentially the same for either alternative, approximately $500,000 per year. The power costs would be the same due to the equal number of pumps and sludge collectors, and the equivalent pump operation times. The stacked clarifiers will require additional maintenance efforts when a stacked set is out of operation, due to the unique entry requirements of the lower clarifier. However, this should be offset by the lower

Table M-5

Summary of Life Cycle Costs
Secondary Clarifiers
(All costs in millions of dollars)

	Capital Cost	O&M Cost	Project[1] Cost	Present Worth January, 1990
STACKED CLARIFIERS				
Equipment	66.0		89.1	54.1
Structures	144.4		194.9	96.5
Annual Operation and Maintenance		0.5		2.0
TOTAL				152.6
UNSTACKED CLARIFIERS				
Equipment	66.0		89.1	54.1
Structures	129.0		174.2	86.2
Annual Operation and Maintenance		0.5		2.0
TOTAL				142.3

[1] Project costs include engineering and contingencies.

maintenance and operation requirements of a smaller, more manageable treatment plant.

SECONDARY CLARIFIERS SITING CONSIDERATIONS

As stated in the introduction to this Appendix, the siting of the stacked and conventional secondary clarifiers includes several siting goal trade-offs. The construction of stacked secondary clarifiers allows for the construction of a berm at the north end of the island large enough to screen the treatment plant from Point Shirley and other areas of Winthrop, as well as to keep the plant as far away from Point Shirley residents as possible. Of the two site layout alternatives, the alternative incorporating a bern and stacked clarifiers provides for the greatest amount of noise attenuation. The layout incorporating stacked clarifiers also provides much more available open space.

Movement of earth on and off the island also varies for each alternative. The quantity of material excavated for the stacked alternative is 780,000 yd^3 out of a total excavation of 3,500,000 yd^3, while the shallower conventional alternative requires excavation of 380,000 yd^3 out of a total excavation of 3,100,000 yd^3. This difference in excavation volume is offset in part by the 220,000 yd^3 of structural fill needed to construct the conventional alternative as opposed to the 60,000 yd^3 of fill needed for stacked clarifiers. The structural fill will most likely have to be purchased and transported to the island. The differences in excavation, fill and earth movement quantities for construction are incorporated in the cost estimates. For the treatment plant layout incorporating stacked clarifiers, the amount of excavation material reused on-site is approximately 2,800,000 yd^3 with an off-site movement of approximately 700,000 yd^3 (excluding off-site removal of demolition and tunnel spoils). For the conventional alternative the amount of excavation material reused on-site is approximately 2,100,000 yd^3 with an off-site movement of approximately 1,000,000 yd^3. The conventional alternative requires an additional 300,000 yd^3 of material to be moved off the island, which is a direct result of the reduction of the size of the berm on the north side of the island.

CONCLUSION

The stacked primary and secondary clarifiers recommended for the Deer Island Secondary Treatment Plant conform to existing design standards and engineering practice and are expected to provide excellent treatment. Data gleaned from Japanese treatment plants' use of stacked clarifiers has been incorporated into the Deer Island planning to ensure efficient and easily-maintained clarifiers. Construction, operation, and maintenance of stacked secondary clarifiers at Deer Island would cost approximately 7 percent more than conventional clarifiers. Also, a treatment plant site incorporating stacked primary and secondary clarifiers most closely meets the site planning goals and project mitigation commitments.

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AMENDMENT TO
SEDIMENTATION USING STACKED CLARIFIERS

During the period of November 30 to December 6, 1987, representatives from the MWRA, Mass DEQE, EPA, and CDM visited the cities of Tokyo and Osaka, Japan to review firsthand the Japanese experience with stacked clarifiers. The trip included meetings with representatives of the Tokyo Sewerage Bureau, Osaka City Sewerage Bureau, design engineers in each city, and tours and interviews with the operating staff at three facilities utilizing stacked clarifiers. This report on that trip serves as an amendment to the preceding section of this appendix, Secondary Treatment Facilities Plan, Sedimentation Using Stacked Clarifiers.

Findings from the trip indicated that stacked rectangular clarifiers have an excellent performance record. The units can be expected to perform identically to conventional rectangular units. The Japanese use identical design criteria for conventional rectangular, stacked rectangular, and circular units. Maintenance of equipment in the lower level has not been a problem. Stacked units have become conventional technology in Japan for primary and secondary clarification.

All of the wastewater plants in Tokyo and Osaka use activated sludge for secondary treatment. The first stacked unit in Japan began operation in 1962 at the Ochiai Plant in Tokyo, and since then the use of stacked units in Japan has become commonplace. Tokyo now has ten wastewater treatment plants, eight of which utilize stacked clarifiers in all, or a portion of, the plant. The first stacked clarifiers in Osaka were constructed in 1966. Currently ten of the city's twelve wastewater treatment plants utilize stacked units. The two plants which do not have stacked clarifiers have aeration tanks constructed directly over secondary clarifiers for space conservation. The current standard practice in Osaka is to use stacked clarifiers for both primary and secondary units. Operating and design staffs in Tokyo and Osaka reported that maintenance of the stacked units has not been a problem. The clarifiers are typically taken down for service once every eight to ten years.

Stacked clarifiers are used in Japan due to severe land constraints. In Tokyo at plants using the stacked units, the ratio of land area to the design capacity of the plant ranges from 0.14-0.48 acres/mgd. In Osaka, this ratio varies from 0.19-0.53 acres/mgd. For the proposed Deer Island facilities, this ratio is 0.16 to 0.19 acres/mgd, depending upon whether plant capacity is based on the primary (1270 mgd) or the secondary facilities (1080 mgd). The three plants visited during the trip had land area to plant capacity ratios of 0.15-0.20 acres/mgd. The site constraints at Deer Island are essentially identical to the typical constraints in Japan which have necessitated the use of stacked clarifiers.

The stacked clarifiers used in Tokyo and Osaka are physically similar except for the outlet weirs. In Tokyo, both the upper and lower levels discharge over weirs set at common elevations at the water surface. Two arrangements have been used: the DDR-1 type uses transverse weirs located at the discharge end of the units; the DDR-2 type uses longitudinal weirs reaching approximately two-thirds the length of the tanks. Officials from the Tokyo Engineering Research and Development Section indicated that future secondary clarifiers may be of the PSR-DDR type, consisting of two or three deep single-decked units at the entrance to the tanks,

with transverse sludge collectors and perforated baffles between each unit, followed by a stacked arrangement.

In Osaka, the primary stacked clarifiers use a DDR-1 type unit. The secondary clarifiers typically use a perforated tube arrangement for effluent discharge, with the perforated tubes arranged perpendicular to the flow and located at the surface of the upper unit and just below the ceiling of the lower unit. This discharge arrangement resulted in hydraulic control problems under varying flows, so in the most recent plants the perforated tubes discharge to small collector boxes at the surface with weirs set at identical elevations for the upper and lower units.

Common design criteria is used for wastewater facilities throughout Japan. The principal parameters for clarifier design are overflow rates and weir loading rates. Identical design criteria are used for circular, conventional rectangular, and stacked rectangular units. There is no reduction in effective area or any other design penalty imposed on the use of stacked units. Data on the hydraulic retention times indicated that stacked and conventional rectangular units behave identically. The overflow rates and weir loading used in clarifier design are presented below.

Unit	Peak Overflow Rate gpd/sf	Weir Loading Rate gpd/ft
Primary Clarifier	1,200	16,000-20,000
Secondary Clarifier	740	10,000-12,000

Weir loading rates are strictly adhered to, even to the extent that the structural configuration of the clarifiers is governed by required weir lengths. In the case of the DDR-2 type unit, the design employed to discharge flows from the lower level units appears to create significant upward velocities that negate any benefits achieved from the long weirs.

Solids loading rates are not considered. However, at the overflow rates used for design and the relatively low MLSS levels typically carried in Japanese plants (MLSS is normally less than 1800 mg/l), solids loading rates would not govern clarifier sizing.

Inlet baffling is an important consideration. Improper location of baffles at the clarifier inlet can accelerate density currents and impact performance. The clarifier inlet typically includes a perforated baffle encompassing most of the cross-sectional area. Japanese experience in rectangular tanks has indicated that there are benefits to utilizing multiple baffles, thus investigating the proposed future use of the PSR arrangement in Tokyo as discussed above.

The most critical design considerations appear to be the inlet and outlet configurations. Flows fed to the upper and lower units behave the same as in conventional rectangular units, but proper design is required to ensure equal hydraulic and solids loadings to each level. The Tokyo plants have had problems with unequal solids loadings to each level during low flow periods, however this has apparently not resulted in degradation of performance, probably since

it occurs during low flow periods when the effective overflow rates are decreased. Unequal solids loadings are the result of solids deposition in the unaerated influent channels. The inlet pipes to the upper and lower units are at different elevations in the common influent channel, resulting in more solids being fed to the lower level. In Osaka, the inlet pipes to the upper and lower levels are set at a common elevation in the influent channel to avoid unequal solids loads.

In order to ensure equal hydraulic loads under varying flow conditions, the upper and lower levels must have effluent weirs set at common elevations. This problem was recognized in Osaka when the initial units with the perforated tube effluent discharge arrangement resulted in unequal flow distribution to the upper and lower units at various flows. As discussed previously, this problem was solved by discharging the effluent collected by the perforated tube arrangement at each level to collector boxes with wiers set at equal elevations.

Removals and effluent quality from the Japanese stacked clarifiers are excellent. Performance data for the year 1985 at the five Tokyo plants utilizing all stacked secondary clarifiers are presented below.

Plant	Ave. Design Capacity mgd	Ave. Flow mgd	MLSS mg/l	Overflow Rate gpd/sf	Solids Loading lbs/sf/d	Eff TSS mg/l
Ochiai	119	122	650	675	5	16
Shingashi	186	123	1500	460	8	4
Kosuge	66	43	1900	470	10	3
Nakagawa	20	3	1900	79	2	1
Kasai	63	40	1600	200	3	3

The overflow rates and solids loadings indicated above are 1985 annual averages. Performance of the stacked clarifiers in Osaka was also excellent with annual effluent TSS from the City's 12 plants ranging from 4 to 13 mg/l. Removal rates from stacked primary units equaled or exceeded that normally expected from conventional units. Operating data from the Japanese plants is not as readily available as it is in the United States. Composite sampling is limited to one or two days per month, with grab samples taken once daily.

Plants visited and the design capacity were:

Plant	City	Capacity - mgd
Shibaura	Tokyo	300
Morigasaki	Tokyo	478
Konohana	Osaka	44

All three facilities had utilized stacked clarifiers in all or a portion of the plant for over

10 years. In addition, the Shibaura plant was undergoing an expansion, including the construction of new stacked secondary clarifiers.

Tours through the three treatment plants included inspection of the upper and lower levels of stacked secondary clarifiers at each plant. Secondary units at the Morigasaki and Konohana plants had been drained several days prior to the tour to allow inspection. The units inspected at the Shibaura plant were new facilities which were complete except for the installation of mechanical sludge removal equipment. Observations from each facility are presented below.

Shibaura, Tokyo. Plant effluent averages 5 mg/l TSS and 7 mg/l BOD. The existing stacked clarifiers, and those under construction, are the DDR-2 type. Identical chain and flights are used in the upper and lower units for sludge removal. Chain and flights in the existing operating stacked units last about ten years. Sprockets and chains are ductile iron and stainless steel, flights are wood. The same wear and failure rates have been observed for the upper and lower levels.

The stacked units under construction that were inspected include provisions for locating multiple baffles along the length of the units. Slots were constructed as set intervals in the concrete sidewalls so that baffles could be installed or removed based upon operational experience.

Morigasaki, Tokyo. Plant effluent averages 3 mg/l TSS and BOD. Stacked clarifiers at the East Morigasaki plant are the DDR-2 type. A set of clarifiers in the east plant had been drained for the first time in eight years. The upper and lower levels were entered for inspection. The floors of both levels had been hosed down, the walls and ceiling of the lower unit had not been hosed. There was no apparent buildup of grease or scum on the ceiling of the lower level. About 1/2 to 3/4 of the ceiling was scraped by the return flights. There was no build-up of materials in the unscraped area and the concrete was hardly discolored.

The chain and flights were in good condition. Plant operators indicated that the clarifiers would probably be returned to immediate service with minimal maintenance. The floors of both levels included grooves to allow hosing and drainage of wash water with stationary flights.

Konohana, Osaka. A set of secondary clarifiers had been drained for the first time in seven years. The upper and lower levels were entered for inspection. The appearance of the units was similar to that of those in Tokyo, with no apparent buildup of grease or scum. However, the flights in the lower units were equipped with rubber blades to assist in cleaning the ceiling on the return sweep. The chains were stainless steel with 13 percent chromium. Plant staff indicated a life expectancy for the chains of about 20 years. The flights were plastic-encased wood. Originally plain wood flights had been used, but the plant had encountered a problem with the flights drying out and splitting when units were taken down for service. Floor drains were provided at intervals equal to the flight spacing to allow hosing with stationary flights.

Secondary Treatment Facilities Plan

Volume III

Appendix N
Abbreviations

APPENDIX N

LIST OF ABBREVIATIONS

atmosphere	atm
average	avg
biochemical oxygen demand (5-day)	BOD
brake horsepower	bhp
British thermal unit	Btu
carbon monoxide	CO
centimeter	cm
chemical oxygen demand	COD
combined sewer overflow	CSO
cubic foot	ft^3
cubic feet per minute	cfm
cubic feet per second	cfs
cubic meter	m^3
cubic yard	yd^3
decibel	dB
decibel A weighted	dBA
degree	deg, or °
degree centrigrade	C
degree Fahrenheit	F
diameter	dia
dissolved oxygen	DO
elevation	elev
feet per minute	fpm
feet per second	fps
food to microorganism ratio	F/M
foot	ft
gallon	gal
gallon per minute	gpm
gallon per day	gpd
gram	g
heating, ventilating and air conditioning	HVAC
Hertz	Hz
horsepower	hp

APPENDIX N

LIST OF ABBREVIATIONS
(Continued)

hour	hr
inch	in
infiltration/inflow	I/I
kilovolt	kv
kilovolt amperes	kva
kilowatt	kw
kilowatt hour	kwh
linear foot	linear ft
liquid oxygen	LOX
meter	m
megawatts	MW
Microgram	μg
milligram	mg
milligrams per liter	mg/l
milliliter	ml
million gallon	mil gal
million gallons per day	mgd
minimum	min
mixed liquor suspended solids	MLSS
mixed liquor volatile suspended - solids	MLVSS
nitrogen oxides	NO_x
parts per billion	ppb
parts per million	ppm
pound	lb
return activated sludge	RAS
revolutions per minute	rpm
second	sec
side water depth	swd
sludge volume index	SVI
sodium hypochlorite	NAOCl
solids retention time	SRT
specific gravity	sp gr
square foot	ft^2
standard cubic foot per minute	scfm

APPENDIX N

LIST OF ABBREVIATIONS
(Continued)

sulfur dioxide	SO_2
suspended solids	SS
tons per day	tpd
total dynamic head	tdh
total suspended particulate	TSP
total suspended solids	TSS
total kjeldahl nitrogen	TKN
ultraviolet	UV
volatile organic compound	VOC
volt	V
waste activated sludge	WAS
watt	w
weight	wt
yard	yd
year	yr

APPENDIX O

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APPENDIX O

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Secondary Treatment Facilities Plan

Volume III

Appendix P
Archaeology

TABLE OF CONTENTS

APPENDIX P

ARCHAEOLOGICAL REPORT

1.0 SUMMARY

This Appendix is a summary of the complete Archaeological Report which will appear in Volume II of the Secondary Treatment Facilities Plan.

The Public Archaeology Laboratory, Inc. conducted an intensive archaeological survey of The New Resthaven historic cemetery site at the Deer Island House of Correction, Boston, Massachusetts. The combined resources of in-depth documentary research, geophysical/remote sensing survey, and archaeological subsurface testing were utilized. The cemetery site is located on the hillside east of the Hill Prison building. Burials are restricted to the area above the mausoleum and extend northeast some 30 to 40 meters. Preservation of the burials within the cemetery is very bad. No further archaeological work is recommended.

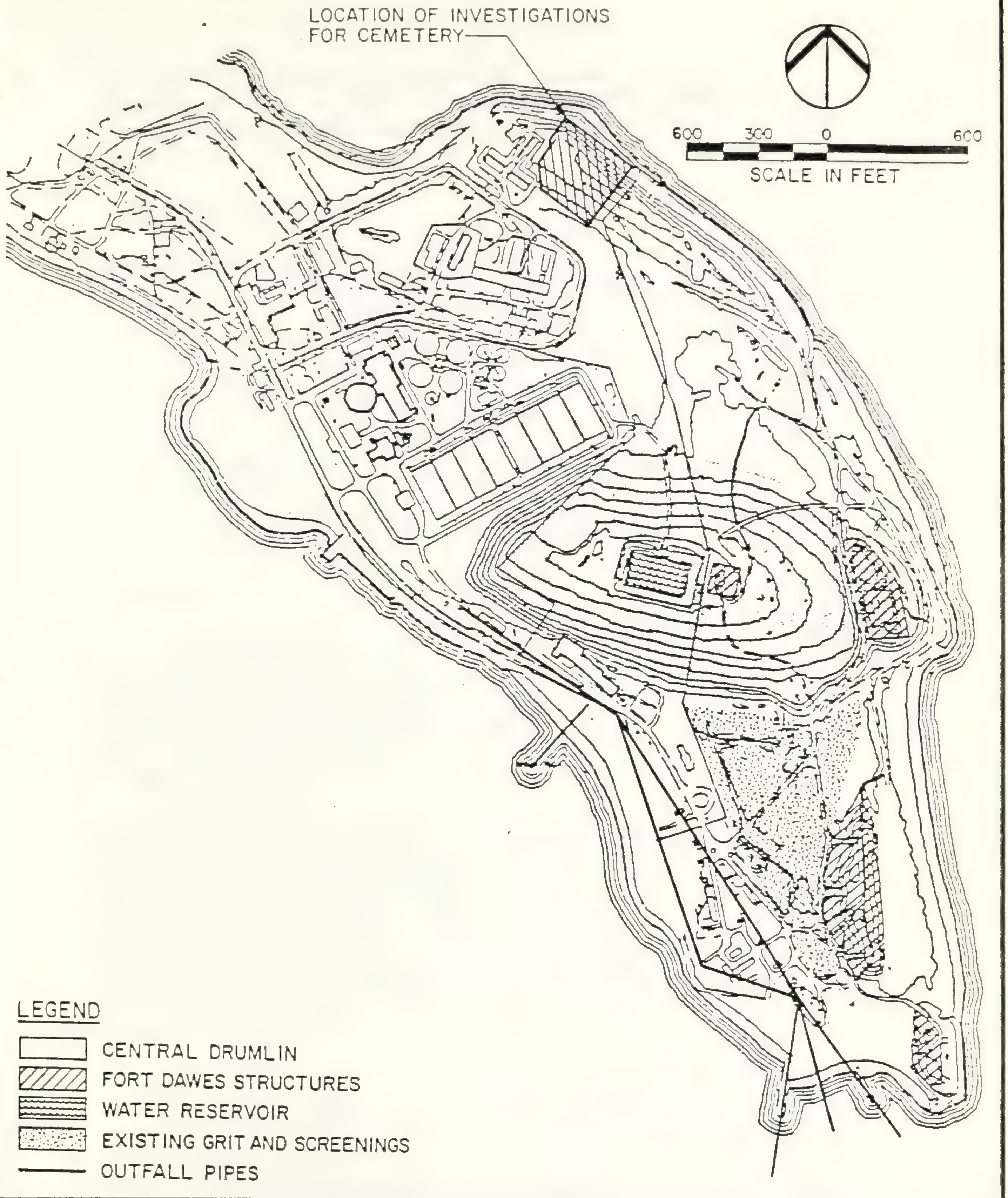
2.0 INTRODUCTION

As part of the planning process for the secondary treatment facilities project, a reconnaissance level archaeological survey was conducted in September 1985 to identify and document standing structures of historic interest and significance on Deer Island and assess the extent of previous disturbance within the designated project area. Another purpose of the reconnaissance survey was to analyze the impact or effect the proposed development would have on cultural resources.

In the course of this reconnaissance survey an historic cemetery and mausoleum were identified within the Deer Island project area. The cemetery plot and associated vault are located on a slope on the northeast side of the island between the old piggery and the concrete boundary wall that originally separated the City of Boston property from the U.S. military reservation on the southern half of Deer Island (Figure P-1). It is referred to hereafter as the northeast, new cemetery, or New Resthaven Cemetery. Based on current plans for the proposed Deer Island secondary treatment facilities Resthaven, it is clear that the cemetery site will be within the area of impact from this development. It was recommended that additional documentary and, if necessary, archaeological investigations be conducted to provide more specific information on the cemetery site.

2.1 <u>RESEARCH TASKS/OBJECTIVES</u>

This intensive survey was carried out in two basic steps or stages consisting of documentary research followed by site verification. Specific research objectives or goals were set for both stages of this investigation. This report describes the results of both stages of research. In-depth documentary research focused specifically on the history of cemeteries



MASSACHUSETTS WATER RESOURCES AUTHORITY	FIGURE P-1 LOCATION OF CEMETERY INVESTIGATIONS

related to the various institutions (quarantine station, almhouse, prison/correctional facilities) that have been located on Deer Island. Site verification, including remote sensing and subsurface testing, focused on the determination of horizontal boundaries and internal configuration of the cemetery.

2.2 DOCUMENTARY RESEARCH

The specific objectives established for the documentary research were: (1) to establish the period of active use of the one known cemetery within the project area (identified during reconnaissance survey); (2) to establish whether this cemetery is older than the 1908 mausoleum associated with it; (3) to determine, if possible, whether the known cemetery contains any burials that were removed from earlier nineteenth century plots formerly located on other sections of Deer Island; (4) to determine if the cemetery plot near the 1908 mausoleum could contain older (nineteenth century?) reinterred burials; (5) to consult records maintained by the military (Army Corps of Engineers) for any information relevant to the final disposal of burials from Resthaven Cemetery; (6) to determine when Resthaven Cemetery on the southern tip of Deer Island was first actively used by the correctional facilities; and finally (7) to locate documentary sources describing the methods used in the burial of the almshouse or prison inmates on Deer Island (individual graves, large trenches, etc).

2.3 SOURCES

A wide variety of sources were consulted in the course of this research. As the City of Boston has no centralized archive or depository for records pertaining to city institutions and no listing of where such documents are located, a major effort was needed merely to track down documentation which has survived intact. During the move to the new City Hall a number of city records were apparently lost or discarded (Captain Swanson and Libby Bouvier, personal communication 1987).

Institutions like those on Deer Island have long and complex histories, particularly when the operation of such facilities has shifted between various city departments or from city to state or federal agencies or jurisdiction. Of primary importance to this research were documents of the different City of Boston boards of directors, committees and departments which have controlled the numerous Deer Island institutions during the past 140 years. Included among these were Annual Reports of the Public Institutions and Penal Institutions departments, the Houses of Industry, Reformation and Correction, the Overseers of the Poor, the Harbor Master and City Auditor. The documents were located in the Massachusetts State Library and provided valuable information.

Unfortunately, although daily and weekly reports of the immediate supervisors of the institutions (including specific information concerning inmates admitted and discharged, physical examinations, visitors to the institutions, and log books of the Houses of Industry and Correction) were located, they were not readily accessible. Many of these documents, some 318 volumes, discovered in the old prison building following a fire, were only sketchily inventoried by Dr. Dennis P. Ryan and Mr. Earl Hamilton in 1985 prior to their transfer to the

library at Boston College for preservation and cataloging (Penal Department Communication 1985). Cataloging and indexing of the collection has not yet been completed. Dr. Ryan, who looked through much of the material, could not remember seeing listings of deaths or burial locations nor information on cemeteries (Dr. Ryan, personal communication, 1987). Mr. Hamilton provided information concerning a "Death Book" maintained at Deer Island. However, as yet, permission has not been received to visit the island and consult this potentially valuable resource.

In addition to the consultation of city documents, the records of the U.S. Army Corps of Engineers at the National Archives and Records Administration Center in Waltham, Massachusetts were examined. The numerous memos, letters and documents relating to the purchase of the military reservation on the southern portion of the island for harbor defense and the subsequent transaction between city and military officials, provided detailed information on the old City of Boston Cemetery located on the military reservation.

Letters were mailed and/or phone calls made to individuals and departments concerned with or knowledgeable about Deer Island. Among those contacted were Captain Swanson of the Metropolitan District Commission, Earl Hamilton of the Penal Institutions Department, Superintendent Broderick and Mrs. Bondar at the Suffolk County House of Correction on Deer Island, the Cemetery Division of the Parks and Recreation Department, Death Section of the City Clerks Department, and Dr. Dennis P. Ryan, a historian of the Boston Irish and consultant to Burns Library at Boston College.

In the course of several trips to Deer Island to conduct the site verification fieldwork, conversations with guards provided additional information. From Officer Kane we learned how the site has been used in recent years, the locations of a guard dog burial and the burial of pig remains following the destruction of the piggery by fire, and of the impact of storms and seawater upon the site. Another guard informed us of photographs in the MDC archives under the care of Alfred K. Schroeder, which were later consulted.

In addition to these primary sources of data, secondary sources on Boston history, Irish immigration, and other related issues were consulted. These sources provided much of the historical background necessary to understand the public institutions established on Deer Island and the inmates who occupied them.

Working within these constraints, this research has focused on the issue of death and burial at the Deer Island institutions to trace the origins and history of the cemeteries on the island. Historical background on the development of the various public institutions is provided to complete and complement this research goal.

2.4 SITE VERIFICATION

The site verification stage of the research involved two steps, remote sensing and subsurface testing. A program of remote sensing was used to discern any patterns of disturbance which may be present in the cemetery area and which could indicate the presence of burials. The remote

sensing program employed two techniques, soil sensitivity and electron magnetometry. A number of anomalies of differing sensitivity were located and ranked by their priority for testing. Based on the results of the remote sensing a plan was formulated for subsurface testing which included machine excavation and documentation of ten possible trenches within the project area.

3.0 PUBLIC INSTITUTIONS ON DEER ISLAND

During the 140 years since the City of Boston took possession of Deer Island in 1847 for "sanitary purposes", the island has served as a repository for individuals and a location for institutions considered undesirable within the core urban area.

More than 25,000 alien passengers, many of them Irish immigrants, arrived in Boston during 1847 (Abbot 1926:589). The numbers of ill and dying arriving in Boston were so great that, during the summer of 1847, a receiving room was constructed at Long Wharf in which these invalids could wait for transportation to hospitals. That year, a quarantine hospital was established on Deer Island for the express purpose of receiving alien passengers "as a precautionary measure to ward off a pestilence that would have been ruinous to the public health and business of the city" (Massachusetts Senate Doc. 46, 1848:10).

Large numbers of these immigrants who were sent to Deer Island never recovered. Of 4,816 persons admitted between the opening of the hospital in June, 1847 and January 1, 1850, 4,069 were sick when admitted and 759 died on the island (Abbott 1926).

In 1849, the City of Boston confirmed its earlier decision to use Deer Island as "the place of quarantine for the Port of Boston" (City Doc. 27, 1849:5). All ships entering Boston Harbor containing passengers or cargo considered to be "foul and infected with any malignant or contagious disease" were required to anchor at Deer Island until such time as the Port Physician gave permission to leave following removal of passengers and cleaning and purification of the vessel (City Doc. 27, 1849:6).

Prior to 1849, the city maintained only one institution on Deer Island, a quarantine station and hospital for immigrants and paupers unable to care for themselves, located on the southern half of the island. Beginning in that year, most of the Deer Island facilities were "occupied as an appendage to the South Boston establishment" of the House of Industry (City Doc. 25, 1849:4). As of March 31, 1849, the Deer Island Department of the House of Industry had 396 inmates. The hospital continued at Deer Island until 1866 when it was replaced by a new hospital on Gallop's Island (Mikal 1873:50).

A brick building was completed in 1852 to house the Deer Island Almshouse and House of Industry located on the northern half of the island. While these two institutions were considered separately in much of the official documentation, a major problem on the island was the close association of the two categories of inmates. The Almshouse was established to serve the virtuous or deserving poor, and these individuals were permitted to live at Deer Island when they were unable to support and care for themselves. Facilities provided for the Almshouse population included a nursery, schools, hospital (shared with other institutions), housing and

workshops.

The inmates of the House of Industry were sentenced by the courts to serve time at Deer Island for misdemeanors and crimes committed in the City, including large numbers of individuals sentenced for drunkenness and idleness. This second category of inmates, the sentenced or vicious poor, were seen as a bad influence on the Almshouse population and on the children within the institution (City Doc. 27, 1857:7; City Doc. 25, 1860:5). However, it was not until construction of additional facilities to relieve overcrowding during the latter half of the nineteenth century that a more or less total separation of the two groups of inmates was accomplished. Meanwhile, the population of those institutionalized grew quickly from the 331 recorded in 1856 to 1,746 inmates in the combined institutions in 1886.

In addition, as early as 1854, Deer Island was being considered for the location of a new House of Correction. In that year the Committee on Public Buildings authorized a portion of the brick building, then housing the Almshouse and House of Industry, to be remodeled by the addition of cells, for use as a prison facility (City Doc. 24, 1856:3). As a result, inmates of the building were redistributed among the other structures on the island, most of them "inadequate and incommodious" (City Doc. 27, 1857:6). In November of 1858, the building was completed and the city poor in the House of Industry were moved into it from the wooden buildings. At this time a portion of the building was also allocated for the use of the House of Reformation. No prisoners from the House of Correction were yet sent to the island.

During the summer of 1858, the House for the Employment and Reformation of Juvenile Offenders-Boys was transferred from South Boston to new quarters at Deer Island. Boys sentenced for misdemeanors such as truancy, larceny and idleness were sent here for discipline (Snow 1971:156). Shortly thereafter, in the fall, a school for girls was established in the House of Industry and became known as the House of Reformation-Girls. Between 1866 and 1873 neglected children were transferred to the Almhouse facilities (Bradlee 1976:9-12). Also present on the island at this time, to serve the needs of children, were the Pauper Boys' and Pauper Girls' Schools within the Almshouse, serving the deserving poor. Until 1869/1870, the children were housed with the men and women of the institutions. After that date, with construction of new facilities, boys and girls were not only separated from each other, but also from adults.

The year 1877 saw a number of changes in population and institutions at Deer Island. Adult female paupers were removed to Austin Farm. The pauper and neglected boys were removed to the Marcella Street Home in Roxbury. This helped to relieve the crowded conditions at the main building. The only paupers remaining at Deer Island Almshouse following this reorganization were the young children in the nursery, pauper girls, and a few adult females too ill to be transferred with the rest (City Doc. 49. 1877:18).

In 1882, a House of Correction was established at Deer Island with the transfer of some inmates from the House of Correction in South Boston. Young men were sent to Concord Reformatory, the rest went to Deer Island. The House of Correction was not considered a reformatory, but "merely a place of punishment and detention" (City Doc. 9, 1887:34). Men were employed in many

occupations on the island, i.e. farming, stone cutting, and manufacturing of a number of items.

In Chapter 536, Section 9, of the Acts of 1896, the institution formerly known as the House of Industry on Deer Island "was established as a Suffolk County Institution, and designated as the House of Correction at Deer Island" (City Doc. 14, 1897:1). A new cell building was completed about this time, providing 500 additional cells. It was not until 1902 that the last of the inmates housed in the House of Correction in South Boston were moved to Deer Island and the consolidation completed. After this date the House of Correction was the only City of Boston institution located on Deer Island. All other inmates in the Almshouse and schools had been moved to other locations.

In 1906, following negotiations between the City of Boston and the U.S. Government, the City deeded nearly 100 acres in the southern portion of Deer Island to the federal government for the construction of a military reservation and harbor defenses (Suffolk Co. Registry Book 3177:577). Included in the stipulations of this transfer was the agreement that the City would build a boundary wall between City and Military reservation property, remove the old piggery and other City property, discontinue cultivation and removal of sand, gravel and sod, and discontinue burials in old Resthaven Cemetery on the new military reservation property (U.S. Army Corps of Engineers).

A sewage treatment plant was constructed on the island in 1889 with a major outlet into the harbor at the south end of the island. In the 1950's some 39 acres of land adjacent to the prison facilities on the south end were taken by the Metropolitan District Commission for an "antipollution and sewer project" (City Doc. 17, 1957:3). The resulting sewage treatment plant was completed in 1968.

4.0 DEATH AND BURIAL ON DEER ISLAND

Documents of the City of Boston indicate that through time Deer Island has become the final resting place for large numbers of individuals. During the forced occupation of Deer Island by "friendly" or "Christian" Indians during King Phillip's War in 1675, many of the Native Americans died. As they were not allowed to leave the island, burial of the dead presumably took place on Deer Island. Sweetser (1883:195) stated that of "500 martyrs to English distrust very many died, and were sadly buried by the moaning and misty sea." The locations of such burials were not recorded and are unknown. No evidence of Native American burials has been recovered from archaeological surveys on the island.

Prior and subsequent to King Phillip's War, Deer Island was leased by the City of Boston to a number of individuals or families (Snow 1971: 199-203). The records do not provide any details regarding deaths or interments on the island by any of these tenants. None of the early maps of Deer Island indicate locations of burials or cemeteries.

Since 1847, when the City of Boston took possession of Deer Island "for sanitary purposes", the island has been the home of various public institutions for the care of both adult and juvenile ill, poor homeless, and sentenced offenders as described above. As such, it has also been the

site of many deaths and subsequent burials of the unclaimed dead. It is on the burials and cemeteries associated with the institutions that this research focused in the effort to determine the dates, identities, methods of burial, and institutional affiliations of the interments in the new cemetery.

The initial years of the Quarantine Hospital and Almshouse at Deer Island was the period of the major influx of Irish immigrants fleeing the potato famine and disease in Ireland. Between 1847, when the institutions were established, and the end of 1849, some 4,816 persons had been admitted. Of this total number, 4,069 were ill upon their arrival at Deer Island and 759 died on the island (Abbott 1926:598). Some 721 individuals were buried on Deer Island during the years 1847-1849. These interments appear to have been made in old Resthaven Cemetery, located on the southern portion of the island, later owned by the U.S. government (U.S. Army Corps of Engineers 1908). The discrepancy between the number of deaths and the number of burials most likely indicates that some bodies were claimed by family or friends for burial elsewhere, while only the unclaimed or indigent were buried at City expense on the island.

From the initially large numbers in 1847 to 1854, deaths and burials on the island declined sharply between 1854 and 1855 along with the drop in immigration to Boston. The number of burials remained low through the Civil War years, increasing in the mid 1870's. The reason for this increase remains unclear, although general economic conditions were bad, possibly leading to greater numbers of poor being sent to the Almshouse and House of Industry.

Deaths and burials on the island decreased with slight fluctuations through the end of the nineteenth century. This reduction in the number of deaths and burials on Deer Island can probably be linked to improved sanitary conditions and health care as well as to the change in the composition of the institutionalized population. Prior to 1896, persons residing at Deer Island institutions were a varied group of men, women and children, many of whom had been living in extreme poverty conditions and were in poor physical condition, if not ill, upon their arrival. After 1896, the population at Deer Island was primarily composed of inmates in the House of Correction who had been sentenced for crimes committed, but had not necessarily been poor or ill before their arrival. In general, this latter population was healthier than those who had preceded them on Deer Island.

The records available, primarily Annual Reports of the various City committees and departments in charge of the institutions on Deer Island, provide little information about the manner in which deaths, funerals and burial were handled on the island. Even the reports of the chaplains at the institutions fail to mention deaths or burials. Only one chaplain's report was noted which mentioned that "funeral and baptismal rites have been attended to when called upon" (City Doc. 14, 1897:51).

Burial on Deer Island was referred to indirectly in several annual reports mentioning construction activities related to burials and cemeteries. In the "Annual Report of the Directors of the House of Industry and Reformation, for the year 1856-1857" construction of new tombs was reported:

> The Tombs, originally located on the north easterly face of the Island, being found unsuited to their purposes, from their exposure to flooding by the action of the sea in severe storms, have been discontinued; and the material used in the construction of new ones in a more secure and suitable position. (City Doc. 40, 1857:4)

Construction of the new tombs was in an undisclosed location. In addition, during the same year, labor was expended in "digging graves for reception and depositing the bodies removed from City of Boston" (City Doc. 40, 1857:21). There is no explanation provided about how many graves were dug or where and why these bodies were removed from Boston for burial on the island.

A morgue was built on Deer Island in 1886 for the use of the various institutions as needed. The annual report for that year refers to the morgue as:

> A neat and appropriate house...for temporary deposit of the bodies who may die, with room for showing the bodies to friends, and where funeral services can be performed when they are not removed for burial in other grounds (City Doc. 9, 1887:38)

Where bodies were buried if unclaimed and not removed from the island was not mentioned in the report. The first mention found in city documents and annual reports of the presence of a cemetery on Deer Island came in the 1909 "Annual Report of the Penal Institutions Department." This report, which post dates the sale of the southern portion of Deer Island from the City of Boston to the U.S. Government, makes reference to city compliance with one of the stipulations in the deed of transfer.

> Owing to the taking of the land from the institution by the United States Government the creation of a new cemetery and receiving tomb were made necessary, and these have been completed. All the bodies in the old cemetery have been carefully transferred. (City Doc. 29, 1909:8).

The old cemetery referred to is "Resthaven (City of Boston) Cemetery at Deer Island" located on the military reservation property, southeast of the gate through the concrete boundary wall separating the City and Federal property on the southern end of the island.

A document and letter on file in the U.S. Army Corps of Engineers records provide information about Resthaven located from City records in 1908 (U.S. Corps of Engineers, 1908).

> [Captain Fredendall] secured from the City of Boston the records showing the number of bodies interred therein and dates thereof, which show this cemetery has been used for the burial of all immigrants dying at the quarantine station or brought in from ships from 1847 to 1882, since which date it has been used for burial of criminals dying at the penal institutions, City of Boston, not claimed by relatives or friends.

Fredendall's letter further indicates that in 1908 Resthaven Cemetery contained 4,160 bodies "interred in lots of eight or ten in trenches."

If "all the bodies" in the old Resthaven Cemetery were removed to the new cemetery, presumably to the cemetery on the northeast hill behind the prison and between the piggery and the boundary wall, this new cemetery would have contained 4,160 bodies as of its creation in 1908. Subsequent deaths and burials of institution inmates would have added somewhat to that number.

Unfortunately, conflicting evidence exists in the U.S. Army Corps of Engineers records suggesting that only the eighteen bodies deposited in old Resthaven Cemetery in 1908, after the final sale of the property, were transferred to the new northeast cemetery. This is substantiated by a letter from the Master of the Suffolk County House of Correction on Deer Island dated December 30, 1908. Master Cronin reported that the 18 bodies in question, those placed in Resthaven subsequent to the sale, had been removed (U.S. Army Corps of Engineers, 1908). His letter does not indicate that "all the bodies" were transferred as stated in the annual report. This conflicting evidence raises some questions as to the exact number of bodies in the newer northeast cemetery.

A memo on Suffolk County House of Correction, Deer Island letterhead stationery dated August 23, 1934, and found inserted between pages of the Death Book maintained by the institution provided additional data concerning death and burials on Deer Island. During 1933 and 1934, ten deaths occurred among inmates. Some of these individuals had been sent to the hospital on Long Island where they subsequently died. Of the ten, four were sent to the Medical Examiner, five were claimed by relatives, and one is listed as "Unclaimed - Buried at Deer Island 7-28-34". The memo further described disposition of deceased inmates as follows:

> After death, the bodies that are unclaimed are put in the tomb on Deer Island, without being embalmed, and are buried in the late summer of each year at Deer Island.
>
> Those who die at Long Island and remain unclaimed are returned to Deer Island.
>
> Cases sent to the Medical Examiner are claimed by relatives in most cases and rarely are the bodies of those unclaimed returned to Deer Island.

An examination of the Death Book maintained at Deer Island House of Correction since 1898 provided information on burials on the island since 1908. According to this source the last burials on the island took place in 1946. The record indicates that 97 bodies were buried on the island between 1908 and the final interments in 1946. Five of these bodies were later exhumed or disinterred, leaving a total of 92 interments. Adding these 92 additional post-1908 burials to the 4,160 reburials believed to be present in the new cemetery brings the total expected body count to 4,252.

A 1923 map of the city property on Deer Island, which accompanied a report considering relocating the State Prison to the island, showed all existing and planned structures, but did not indicate the cemetery plot nor the associated receiving tomb. Documentation indicates that the cemetery was in active use at this time. The cemetery does appear on a 1946 U.S.G.S. topographic map and on current maps.

Current practice on the island with regard to deceased prisoners is to call a Boston mortuary to pick up the body. Following an autopsy the death is logged in the prison death book and the body is either turned over to relatives or, if unclaimed, is buried in a City pauper cemetery such as Mt. Hope Cemetery (Hamilton, personal interview, 1987).

An interview with Mr. Earl Hamilton of the Penal Institutions Department, and a former Superintendent of the Suffolk County House of Correction at Deer Island provided additional evidence concerning the new northeast cemetery (personal interview, 1987).

A photograph in Mr. Hamilton's possession, roughly dated to the 1920s, appears to show the cemetery in the upper center as a large area stretching from the piggery to the boundary wall and tightly filled with white wooden crosses. Judging by this photo it appears likely that indeed all 4,160 bodies from old Resthaven had been transferred and reinterred in the new Resthaven cemetery above the Hill Prison building.

A number of photographs obtained from Alfred K. Schroeder at the archives of the MDC in Boston show New Resthaven Cemetery in the background. One photograph labeled "Sept. 1939, Naval Direction Finder Station, Deer Island" shows the cemetery on the slope behind the Hill Prison building. Approximately 79 white crosses are clearly visible on the slope above the mausoleum and immediately adjacent to the cement boundary wall. The slope area further northeast, closer to the piggery, appears as a rectangular blurry white area. It is unclear whether this was due to a large number of white crosses, or whether the area had been excavated or somehow disturbed. Other pictures probably dating to the 1940s definitely show a white picket fence forming the northern boundary of the cemetery and separating it from an apparently empty field extending to the piggery. At least some of the white wooden markers remained standing in a 1958 photograph. By 1963, most of the individual wooden crosses were gone, leaving only the larger concrete cross which remains today.

Mr. Hamilton (personal communication) knew of no reason to believe that these bodies had been removed from the island since the pictures were taken, even though sometime prior to the 1970s the practice of sending details of prisoners to paint the crosses and maintain the cemetery had ceased. The condition of the cemetery had been allowed to deteriorate until it was barely recognizable as a cemetery in 1985.

5.0 GEOPHYSICAL/REMOTE SENSING SURVEY OF CEMETERY AT DEER ISLAND

Electrical resistivity and proton magnetometer surveys were conducted at Deer Island as part of an archaeological locational survey for The PAL, Inc. The process of geophysical survey was chosen for its ability to detect subsurface disturbance in the soil and guide excavation for the location of unmarked burials.

Geophysical survey has been used as a locational tool in archaeology since the late 1940s. First used extensively in Britain, both the equipment and the method have been developed and refined over the years. Background and development information can be located in the

literature (Aitken 1958, 1974; Atkinson 1946, 1963; Breiner 1973; Carr 1976, 1977, 1982; Eve and Keyes 1954) and an increase in field use can be evidenced by recent publications (Frese 1984; Frese and Noble; Klasner and Calengas 1981; Mason 1984; Parrington 1979, 1983; Shapiro 1984; Weymouth 1976, 1979, 1986; Weymouth and Nickel 1984; Weymouth and Woods 1984).

A number of rectangular and square blocks were surveyed in the project area using two geophysical methods, as these two methods are sensitive to different properties, and a complete geophysical archaeological survey should include multiple methods (Gumaer et al. 1984a).

Figure P-2 shows the location of the testing units used during the sensitivity testing. A total of eleven 20 x 20 m blocks or partial blocks were surveyed (labeled #1 - #11) as well as a large rectangular unit (labeled OMNI). The eastern edges of Blocks 3, 4 and 5 were reduced in size due to the presence of the eroded embankment. Block 5 is small due to time constraints, while Block 7 was shortened by the concrete boundary wall. Electrical resistivity was measured in Blocks 1 through 10. Proton magnetometer readings were taken in Blocks 1, 2, 8, 11 and OMNI. Measurements were taken at one meter intervals along both the X and Y coordinates of one meter interval grid blocks. Data was entered into a computer and analyzed through the use of the computer graphics program SYMAP (Dougenik and Sheehan 1975).

5.1 ANALYSIS OF GEOPHYSICAL DATA: EXPECTED TARGETS

Locating areas of anomalous variation in geophysical data is a problem of spatial patterning. An area will have natural variation affected by its soil makeup. Human activities which penetrate the ground surface can change aspects of the soil which can be detected by geophysical prospecting. The particular target for this field survey was the location of unmarked burial remains within an area known to be used as a cemetery during historic times. Background research showed that the majority of the remains had been moved to this location from another area in 1908 while the rest are the remains of prisoners from the adjacent prison. While both groups of burials would leave behind similar subsurface disturbance, those moved from another cemetery after already having been in the ground for a number of years, in many cases without a coffin, may not be in singular graves and would disturb a larger area.

5.2 RESISTIVITY

Moisture content, granular size, density, and chemical content are factors which contribute to soil variations which are detectable by resistivity survey. The shaft feature from the excavation and refilling of a burial will be detectable as higher resistance. Even after hundreds of years, the soil within the shaft will contain more air space between granules than the surrounding soil. This results in a reduction in conductivity which registers as higher resistance. This type of anomaly has enabled the location of similar grave features elsewhere in New England (Gumaer 1985).

5.3 MAGNETOMETER

Mineral content of soil, specifically the presence of magnetite or related minerals, will

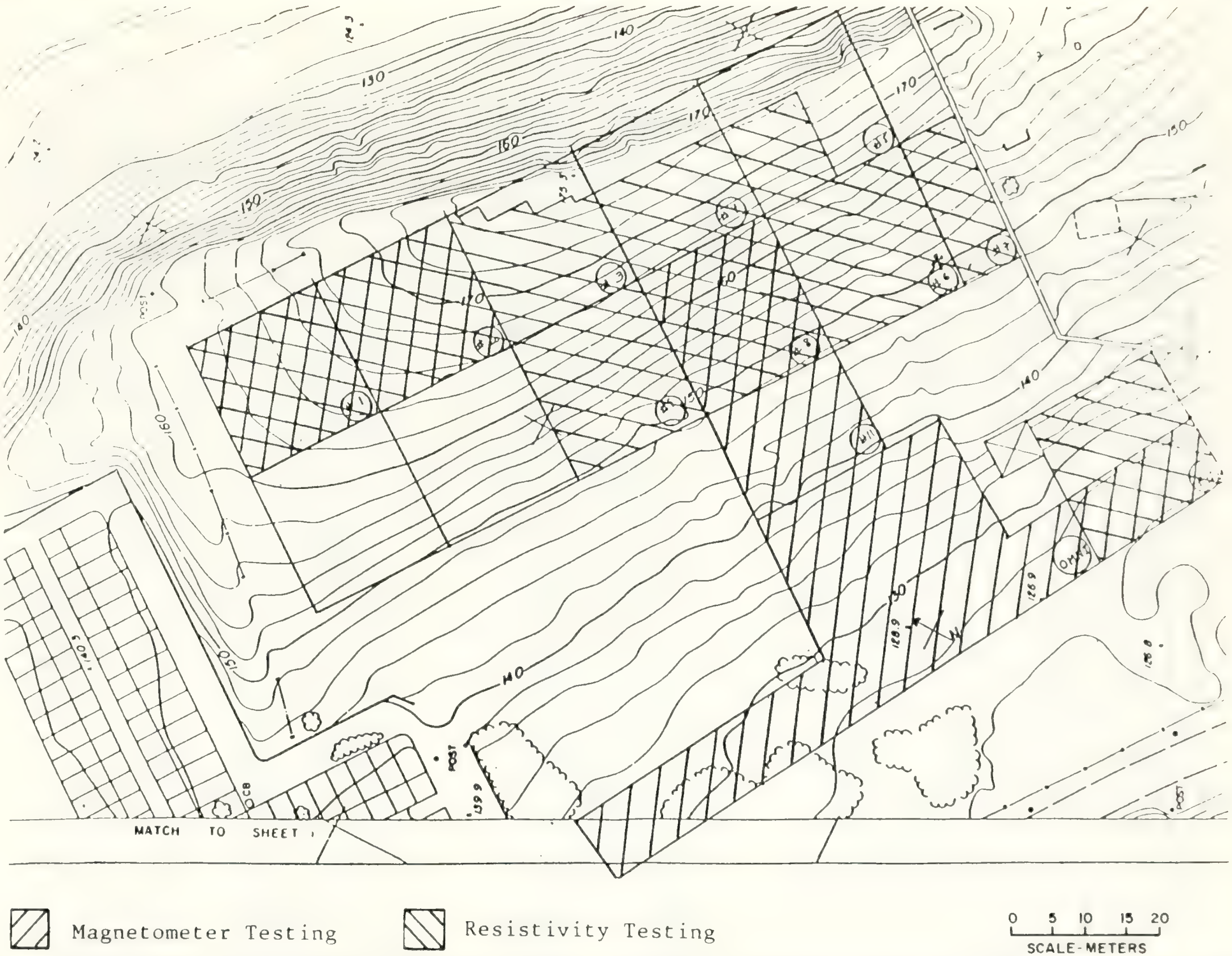


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FIGURE P-2

LOCATION OF SENSITIVITY TESTING UNITS

affect its magnetic susceptibility (Breiner 1973). Soils and rocks may be magnetically enhanced by induction or by remanence. Induced magnetization is directly related to the percentage of magnetite in the soil or rocks. Naturally occurring features such as large boulders containing magnetite can also create a strong enough field to be seen as dipole or monopole anomalies. Anomalies targeted during surveys of prehistoric features are largely the result of thermoremanence. Soils or rocks are heated in a reused fire hearth and the heating allows the magnetic properties or domains (Aitken 1961:18-19) of the minerals within to become unfixed and gravitate towards alignment with the earth's magnetic field. Upon cooling, the properties are fixed once again. The more reheating episodes, the stronger the magnetic field in the soils and rocks are enhanced (Tite and Mullins 1971:216-217). Anomalies caused by the digging and refilling of holes will mix the magnetic domains of the soil and will register as areas of slightly lower magnetic intensity. Historic burials may also offer a different target anomaly if a coffin is used which contains metals having magnetic properties such as iron. With this in mind, areas both above and below the mean will be of interest for the Deer Island data.

5.4 COMPUTER SOFTWARE

SYMAP can be used to produce contour representations of the data as well as to manipulate the data with smoothing routines such as nearest neighbor averaging and trend surface analysis, plotting the trend or the residuals. This type of preliminary analysis can be useful in filtering out natural variation and locating areas of interest that can be field checked. While newer, more sophisticated methods of gray scale have been shown to enhance thin line geometric structures (Scollar et al. 1986), standard contour-type computer plotting is still an inexpensive and rapid first technique for analysis.

5.5 ANOMALIES

A number of anomalies were located as a result of the two techniques employed during the geophysical survey. Figure P-3 shows the locations of these anomalies. It is keyed to indicate anomalies of different relative sensitivity or priority. The high priority areas are those anomalies with the greatest probability of reflecting the presence of burials. Anomalies of low or medium sensitivity were considered more likely to reflect other types of disturbance, such as building debris, fence lines, or change in slope, soil type, or moisture content.

Two anomalous areas were of special interest. These were the high priority anomalies in Block 8 and in Blocks 6 and 7. The pattern of relatively small, discrete anomalies between the 164-foot and 148-foot contour lines in Block 8 strongly suggested the presence of individual burials. The large anomaly in Blocks 6 and 7, up the slope from the concrete cross, suggested the possible location of a mass burial, possibly the early twentieth century reinterment.

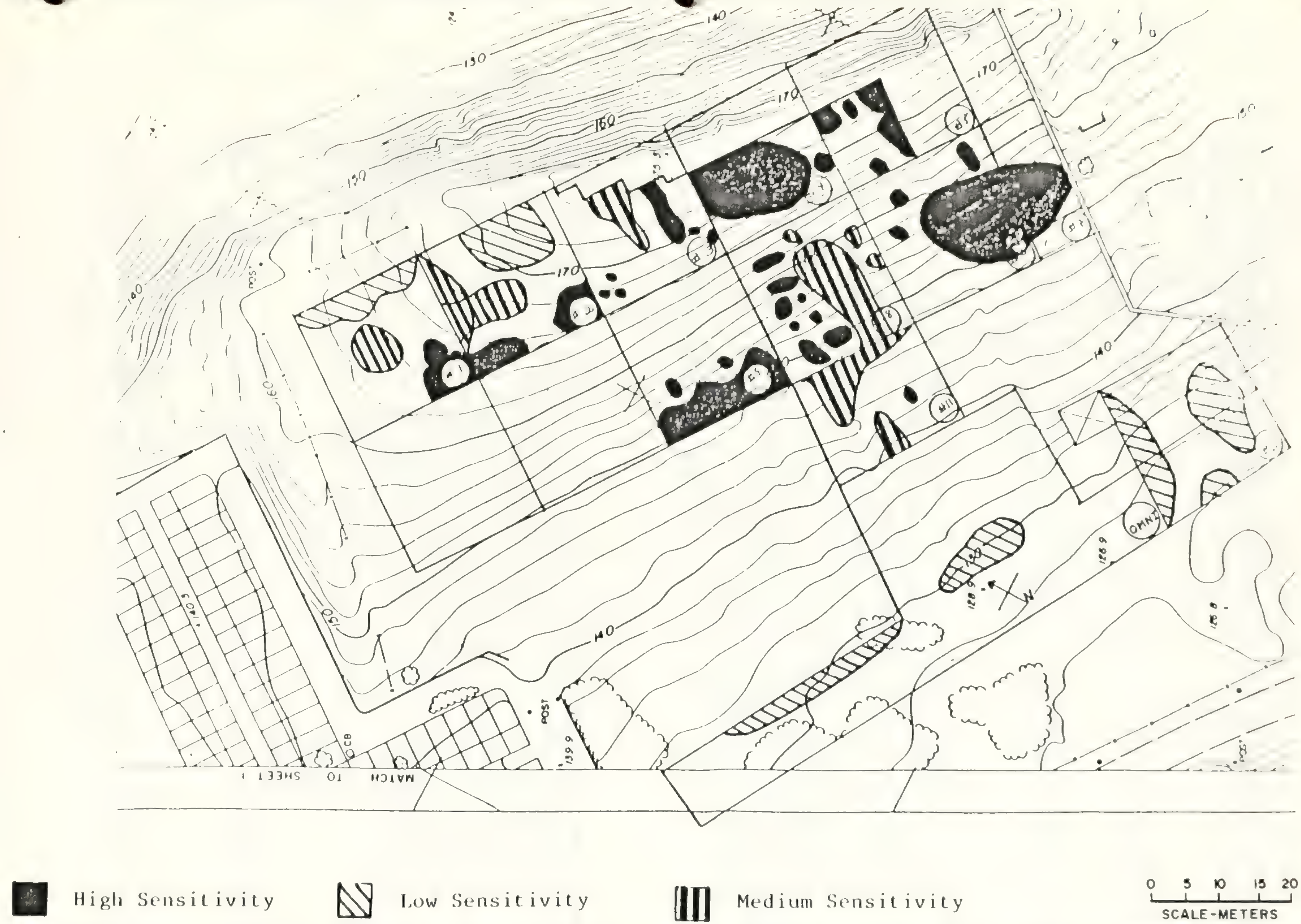

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FIGURE P-3
ANOMALIES LOCATED DURING GEOPHYSICAL SURVEY, DEER ISLAND

6.0 SUBSURFACE TESTING

The final stage of the intensive survey was the subsurface testing of the cemetery site. A site verification testing plan was developed based upon the data collected during the in-depth documentary research and the remote sensing results. The primary objectives of this fieldwork included:

(1) Determination of the horizontal extent of the cemetery through systematic subsurface testing.

(2) Collection of sufficient data to reconstruct the internal configuration or plan of the cemetery and general mode of burial (individual graves, multiple burial in trench, etc.) used at this site.

In 1987, the hillside between the concrete boundary wall and the piggery show few evidences of the old cemetery. The stone and brick mausoleum remains, as does the white concrete cross standing on the slope above. The grass appears more lush and green with fewer coarse weeds immediately above the mausoleum and adjacent to the boundary wall. The portion of the field nearer the piggery is covered in coarser grass and weeds which in some areas are very low and in others fairly high. The ground surface is strewn with historic sheet refuse, including broken pieces of hotel or institutional hardwhite ceramics, glass, metal fragments and a few pieces of wood. The amount of surface historic trash seems to increase with distance northeast from the concrete boundary wall and cross. These may both be indications of the location and northeastern boundary of the cemetery.

6.1 <u>TRENCHES</u>

A total of ten trenches were excavated using a combination of machine-assisted and hand excavation techniques. Figure P-4 shows the locations of these trenches, which were aligned to cover as much of the project area as possible. Due to the sloping surface of the hillside the location and alignment of several trenches were changed slightly in the field to accommodate the backhoe. Trenches 1 through 6 were placed to examine the extent and configuration of the cemetery in general and specific anomalies located by the remote sensing survey in particular. Trenches 7 through 10 were laid out to test the cemetery boundaries indicated on the 1920s photograph of the cemetery. They extend beyond the documented boundary to include marginal areas that might have been used as a burial ground before and after the date of that photograph.

The trenches were excavated by backhoe only to a depth thought to be sufficient to identify a filled burial shaft or mass burial. The depth of the trench beneath ground surface varied, but never exceeded 1.5 m.

The results of the trench excavation are detailed in Table P-1. With the exception of Trenches 1 and 8, the soil matrix was a medium brown, very rocky to gravelly sandy loam (A2) overlying a yellow to orange brown, loamy to coarse sand subsoil (B1). Soils upslope, above the 140 foot

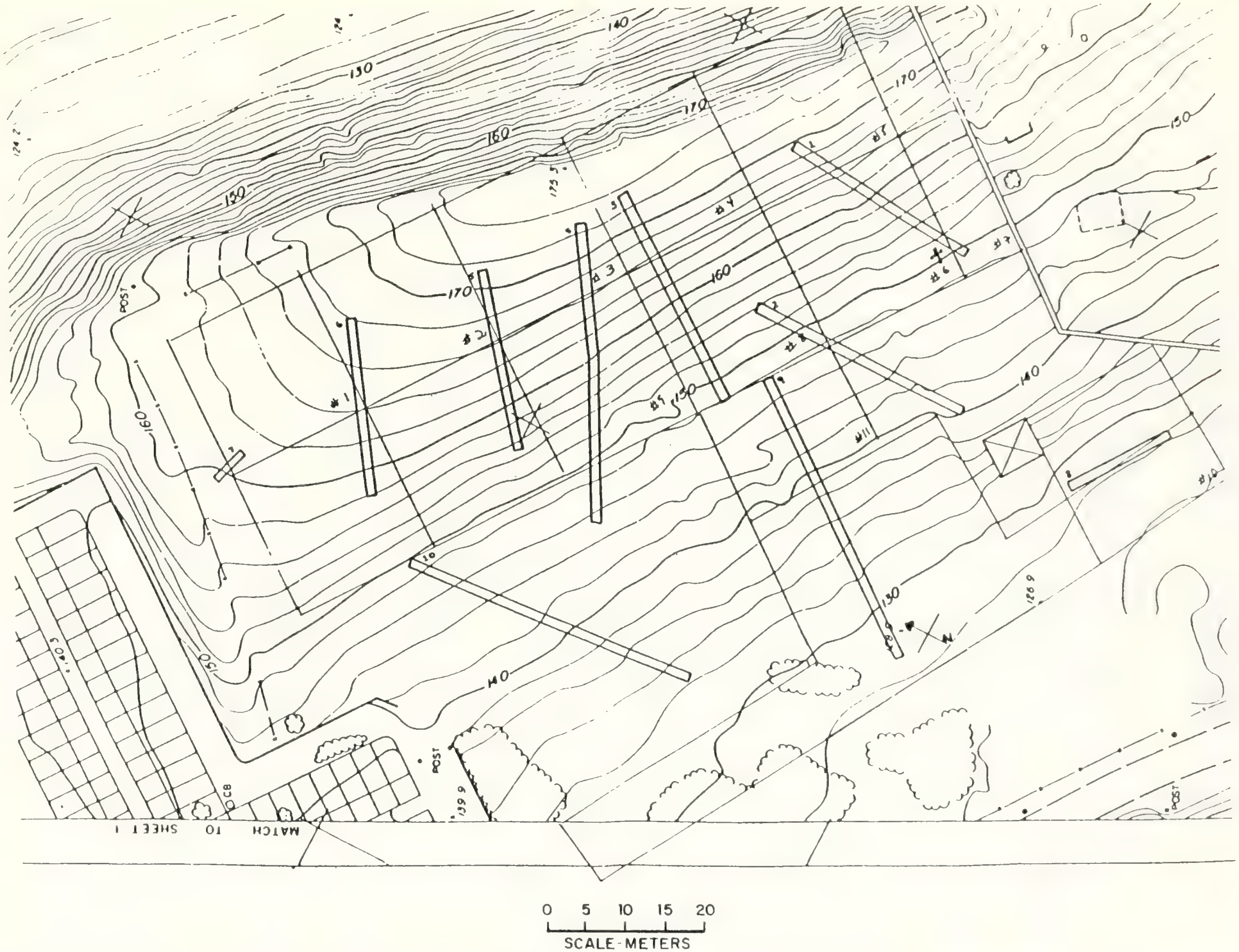

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FIGURE P-4
LOCATION OF MACHINE EXCAVATED TRENCHES

TABLE P-1

TRENCHES EXCAVATED DURING SUBSURFACE TESTING, DEER ISLAND

TRENCH NO.	LENGTH (M)	FEATURE NO(s)	SOIL CONDITIONS	ARTIFACTS
1	26.5	1 & 2	medium brown sandy loam	hardwhite, porcelain wood, nail
2	30	-	rocky upslope	hardwhite animal bone
3	26	-	very rocky	hardwhite
4	39	-	heavy, gravel upslope; rocky sandy loam downslope	hardwhite, animal bone
5	24	-	very rocky; some large rocks shallow A2	hardwhite
6	23	-	gravelly	hardwhite, milk glass
7	5	-	rocky	hardwhite
8	15	-	deep silty loam	hardwhite, nail animal bone
9	40	4	rocky soil upslope; clayey on slope, darker less gravelly downslope	hardwhite, stoneware flatware, animal bone
10	38	3	very rocky upslope, thick dark sandy loam downslope	hardwhite, glass, shell, much animal bone

contour line, tended to be coarser and more rocky than those on the lower portion of the slope. Trench 8, located in front of the mausoleum near an old pond/wetland, had a much thicker medium-to-dark-brown silty loam topsoil. Trench 1, even though it was located upslope, above the 150 foot contour line, had a thick medium-brown, sandy loam topsoil without rocks or gravel.

At least a small amount of hardwhite ceramic, nineteenth to twentieth century hotel/institutional ware, along with some porcelain, glass, and metal fragments, was found in each trench. It was found in greater amounts in Trenches 3-10 than in Trenches 1 and 2. Butchered animal bone, primarily cow and pig, was found in Trenches 2, 4, 8, 9 and 10. The largest amount of this bone was located near the lower end of Trench 10 where most of a pig skull was recovered. Decayed wood and a nail were recovered from the lower end of Trench 1 near the concrete cross (Table P-1).

Shovels and trowels were used to scrape down and clean off trench walls in an effort to locate possible features and for recording profiles. In addition, the bottom of trenches was shovel-scraped in areas which showed the potential to yield additional information.

A total of four features was located (Figure P-5). Two were located in Trench 1, Features 1 and 2. Feature 3 was discovered in Trench 10, and Feature 4 in Trench 9. Only Features 1 and 2 appeared to be related to the cemetery (Figure P-6). After close examination both were determined to be graves.

6.2 FEATURES

Feature 1 was located at the lower end of Trench 1 some 2 meters south of the base of the concrete cross. It first appeared in the trench profile as a slightly darker, mottled orange-brown and dark brown sandy soil containing some wood fragments and one coffin nail (Table P-2). The trench floor was shovel-scraped and troweled and the area of dark soil could be seen extending approximately .75 meters across the trench floor to an apparent corner (Figure P-7). A .5 x .5 meter judgemental shovel test pit (JTP 1) was excavated into the feature. Excavation of this unit proved that Feature 1 was a grave shaft containing a badly deteriorated wooden coffin and poorly preserved human bone (Figure P-8). Both the wood and bone were soft and spongy. The coffin appeared to be oriented perpendicular to the slope of the hillside.

A second grave, Feature 2, was located in Trench 1 above Feature 1. As with Feature 1, this grave shaft was first noted in the profile of the south wall of the trench as an area of mottled medium and dark brown sandy loam (Figure P-7). The trench floor was then shovel-scraped and troweled to determine the orientation of the grave shaft. Feature 2 also appeared to be a roughly rectangular feature oriented perpendicular to the slope of the hillside. Based upon the results of the excavation of JTP1, it was not considered necessary to excavate a similar unit in this feature.

Feature 3, located between the 142 foot and 144 foot contour interval on trench 10, was a different type of feature (Figure P-5). This distinctive feature consisted of a band of dark

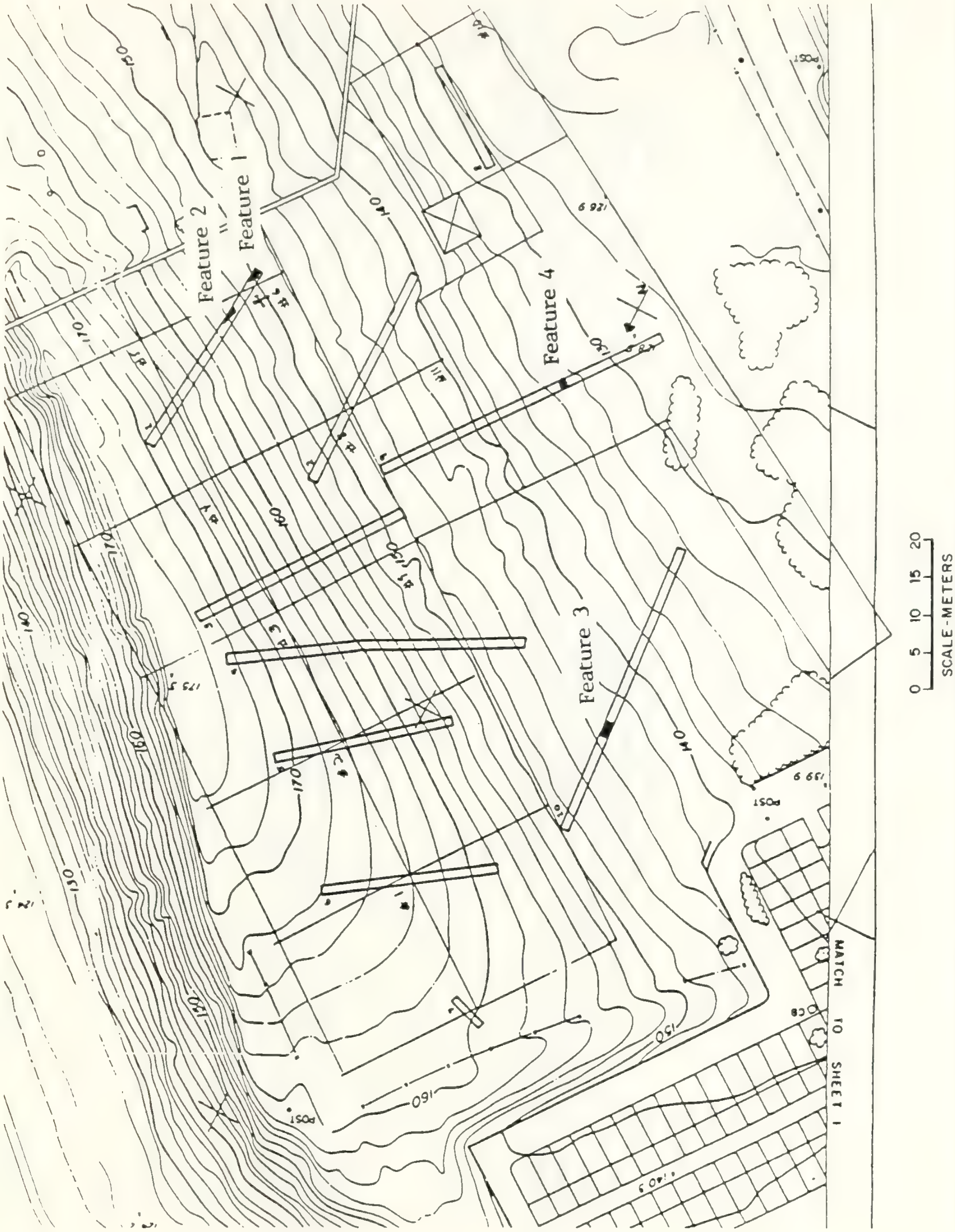

FIGURE P-5
LOCATION OF FEATURES

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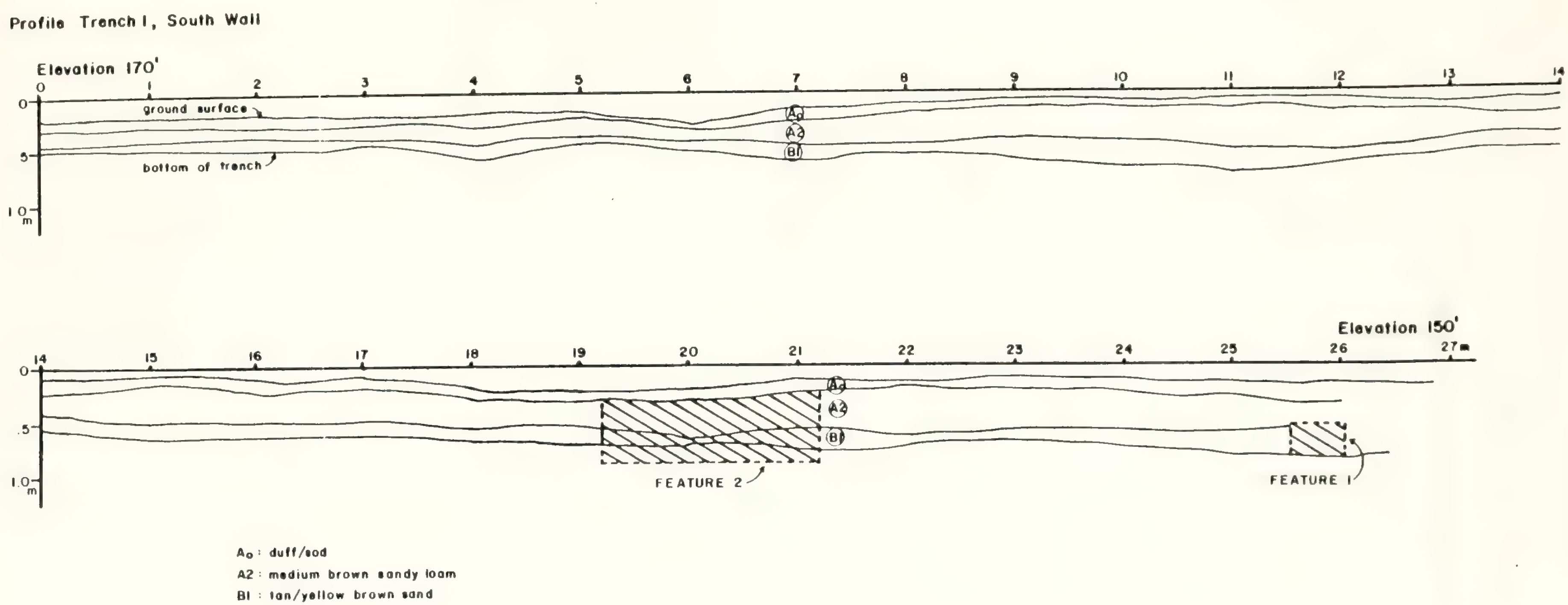

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FIGURE P-6
TRENCH 1 PROFILE

TABLE P-2

FEATURES LOCATED DURING SUBSURFACE TESTING,

DEER ISLAND

FEATURE NO.	TRENCH NO.	TYPE	SOIL	ARTIFACTS
1	1	grave	mottled orange and dark brown sandy loam	coffin wood and nail, bone
2	1	grave shaft	mottled medium and dark brown sandy loam	none
3	10	possible drain	distinct areas of rocks and dark brown silty loam	metal tankard, shell, metal, stoneware
4	9	possible trash pit	mottled medium brown and dark brown	animal bone, metal

Plan view Trench I, Feature I
at lower/west end of trench

Plan view Trench I, Feature 2

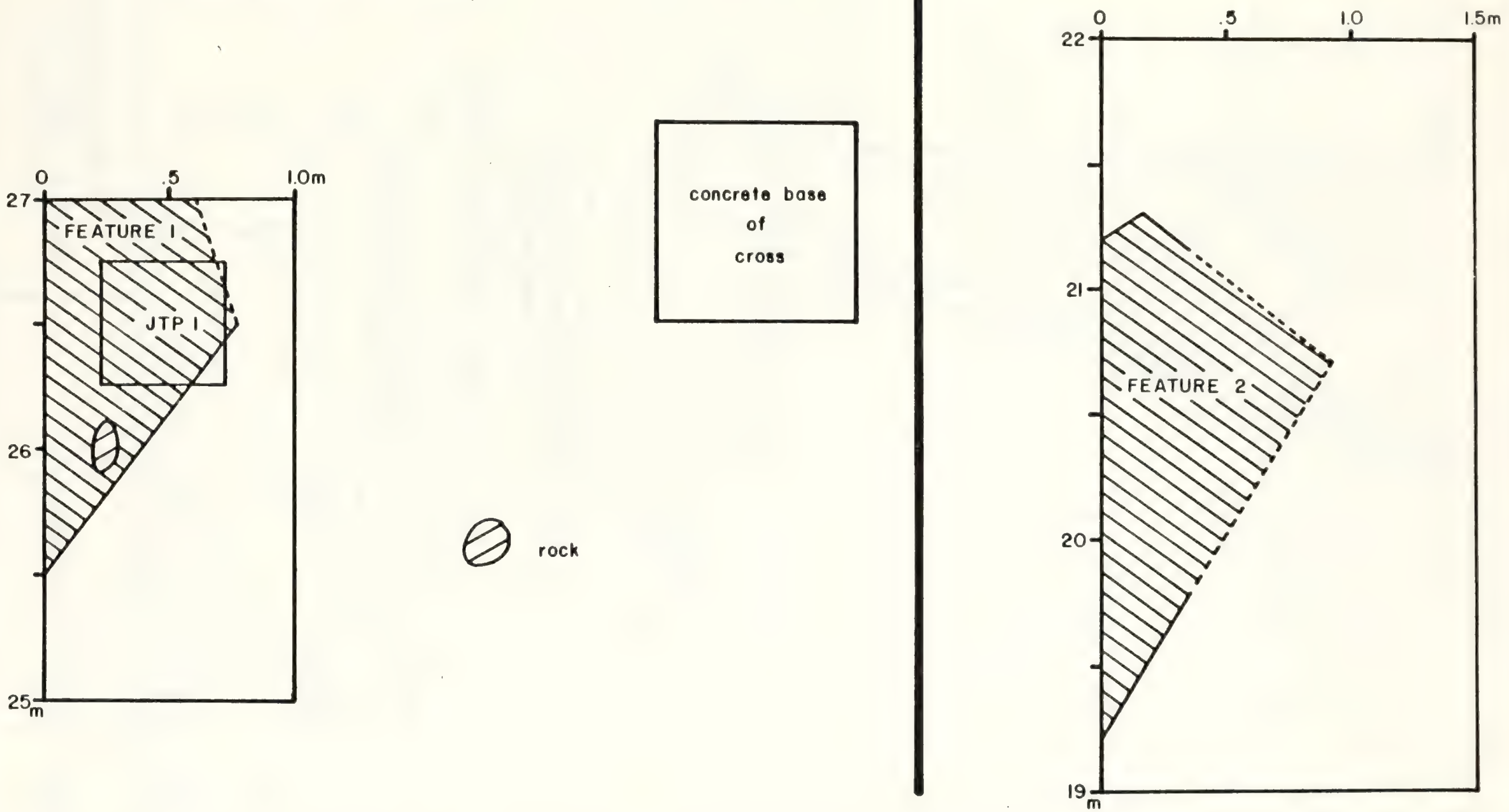

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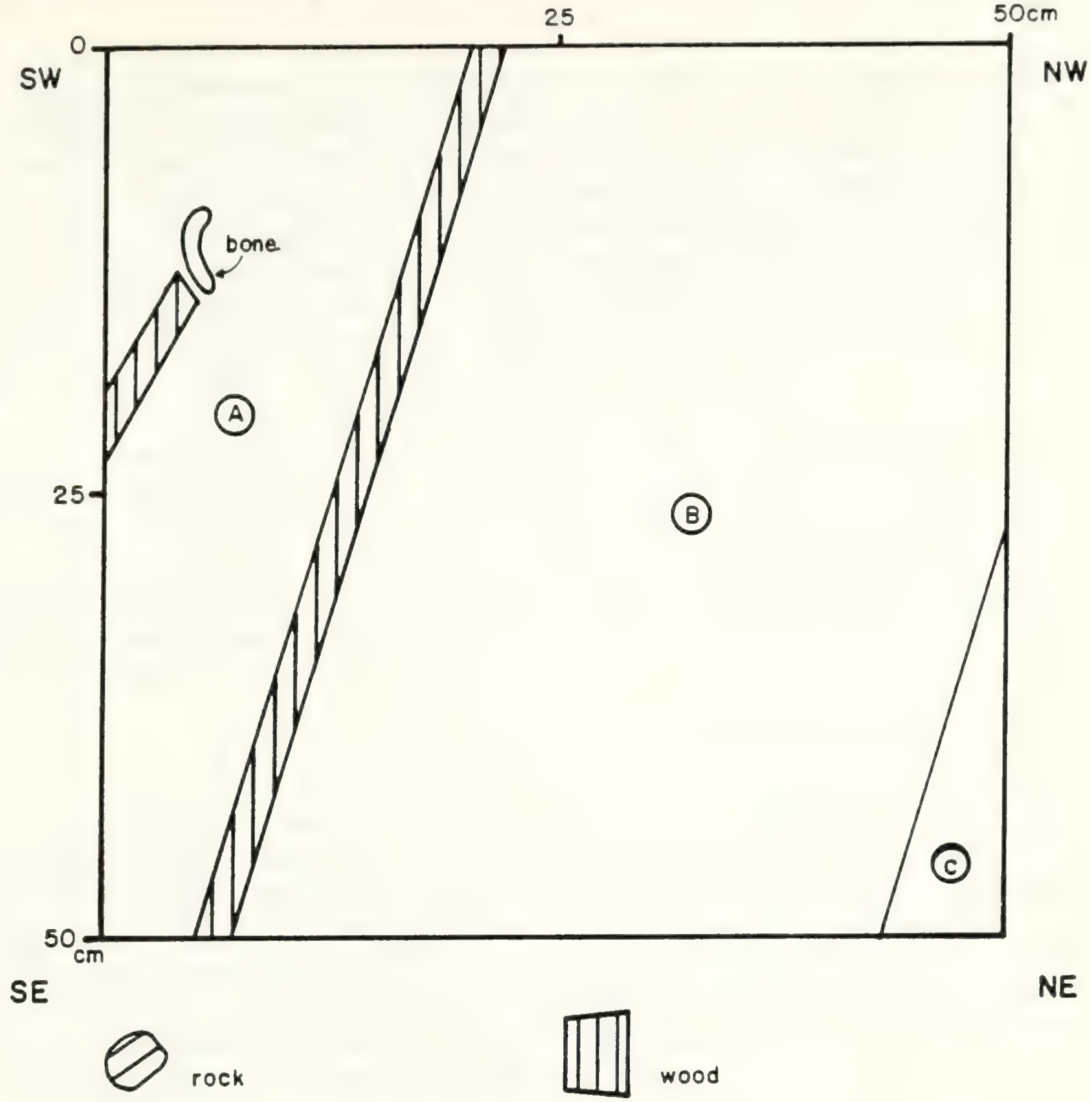
FIGURE P-7
TRENCH 1, FEATURES 1 AND 2 PLAN VIEWS

Plan view Trench I, JTP I at 97cm dbs



A: mottled medium and dark brown

B: mottled orange brown and dark brown

C: mottled yellow brown

Profile Trench I, JTP I of East Wall

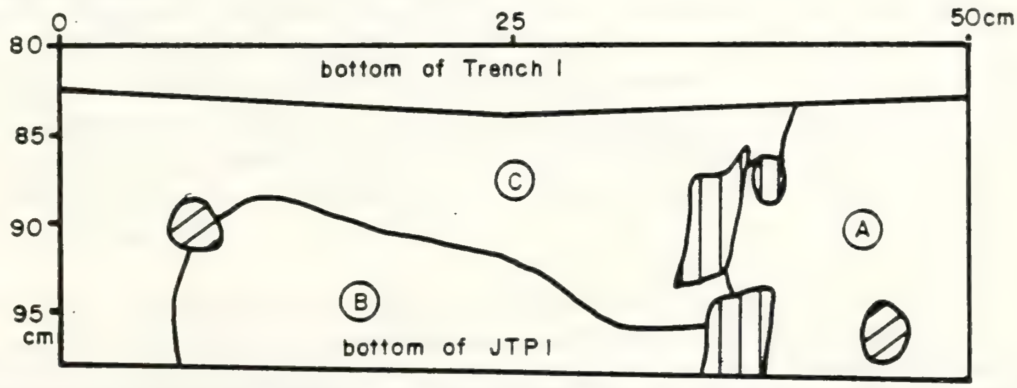


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FIGURE P-8
FEATURE 1, JTP1, TRENCH 1

brown silty loam approximately 1.0 to 1.25 meters wide running across the trench floor adjacent to and upslope from an area of loosely packed rocks (Figure P-9). The top of the rocks began approximately .8 meters below the ground surface and they extended down some 30 to 60 cm. A small amount of clam and scallop shells, metal fragments, one piece of stoneware, and what appeared to be a crushed metal tankard were found between and among the rocks (Table P-2). Feature 3 is possibly a drain used to channel runoff from heavy rains, and/or seawater wash during high seas, from the lower slope and portion of the inland currently housing the prison. This feature could date to a pre-institutional occupation of the island, or to the early institutional period. Feature 3 does not appear to be related to the cemetery.

Feature 4 is a small pit feature located in Trench 9 (Figure P-5). It consists of a pit extending from approximately .2 to .8 meters below the ground surface and 1.0 meters wide (Figure P-10). The upper portion of the pit was filled with a mottled brown sandy loam while the lower portion was dark brown in color. A small amount of greasy black charcoal was visible along the line separating these two layers of pit fill. A piece of animal bone and a fragment of metal were located within the upper fill (Table P-2). Feature 4 appears to be a small trash pit and is probably not related to the cemetery.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The primary goal in this research has been to discover as much information as possible concerning the cemetery located on the northeast slope behind the Hill Prison building on Deer Island in Boston Harbor. The major questions examined have related to the age of the cemetery, its period of active use, its institutional affiliation, the number of individuals buried, the method of burial, the size of the cemetery, its horizontal boundaries, and the interral configuration of the cemetery. Documentary evidence provided information on many of these questions. Remote sensing and subsurface testing were less successful, but did substantiate the presence of burials in a portion of the project area.

During the course of the in-depth documentary research, contradictory evidence was uncovered concerning the origins and development of the northeast cemetery. After consideration of all the evidence it appeared most likely that the cemetery in question is "New Resthaven Cemetery" created in 1908 with the reinterment of some 4,160 bodies from old Resthaven Cemetery in the military reservation on the southern portion of Deer Island. The cemetery, at its present location, is 79 years old, or greater than 50 years in age. In addition, 2,559 of the bodies reinterred in new Resthaven are 100 years in age or older, many of them being quarantine hospital victims and Irish immigrants. An additional 92 unclaimed bodies were interred in the cemetery subsequent to its creation. The last recorded burials on the island occurred in 1946 (Deer Island House of Correction Death Book). As no evidence has been found suggesting the removal of these burials to another location, it is expected that some 4,252 bodies remain interred in the cemetery.

The documentary research initially suggested that the northeast cemetery plot, or New Resthaven, was potentially much larger than expected from the cursory field inspection of the site. Judging by the 1920s photograph, the cemetery appeared to extend from the northeast wall

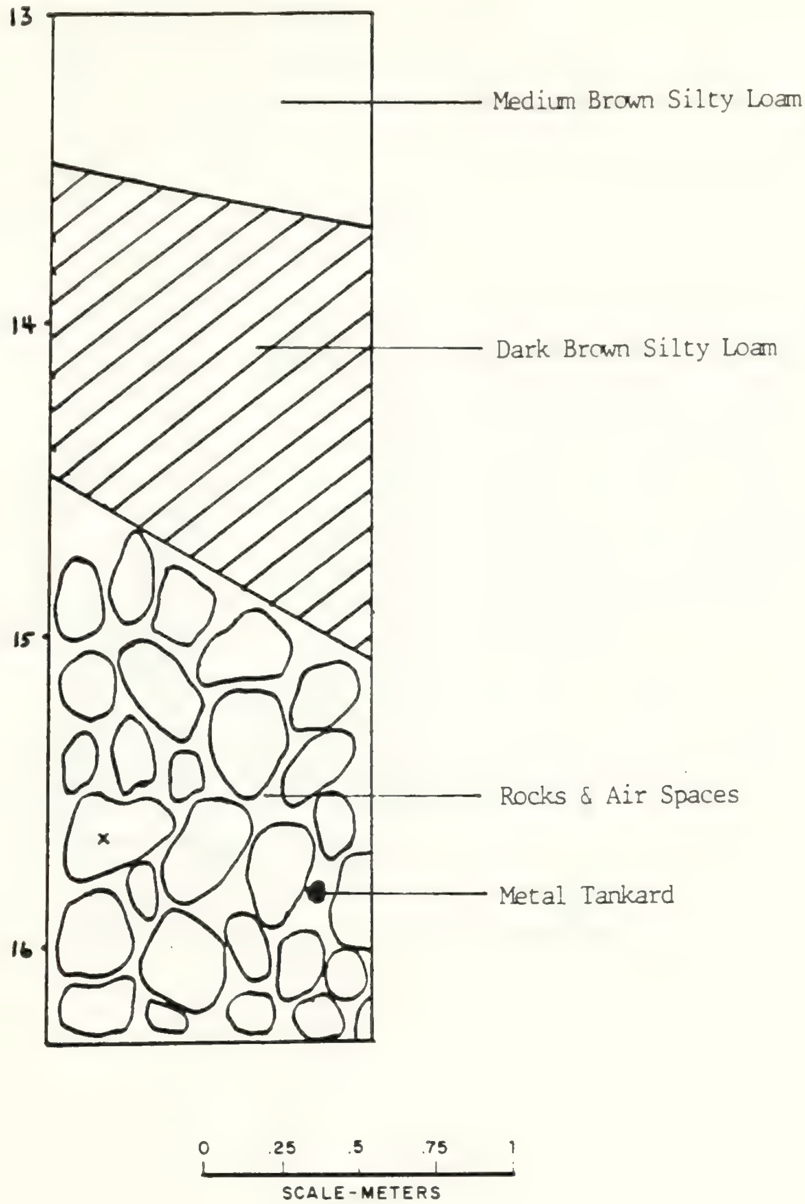

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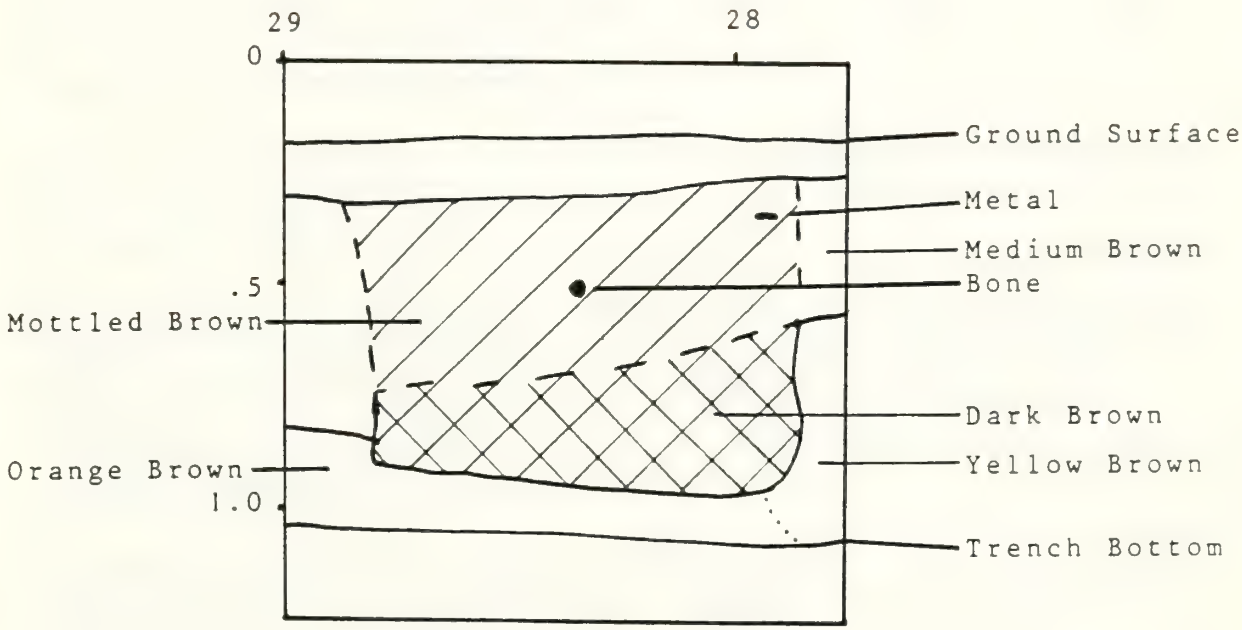
FIGURE P-9
FEATURE 3, TRENCH 10, POSSIBLE
DRAIN PLAN



MASSACHUSETTS WATER RESOURCES AUTHORITY	FIGURE P-10 FEATURE 4 PROFILE

of the old piggery to the cement boundary wall and from the sea wall at the top of the slope to the mausoleum at the foot of the slope.

The 1939 and 1940s photographs, acquired recently, show less extensive cemetery boundaries. This smaller cemetery plot is restricted to the portion of the slope above the mausoleum, from the cement boundary wall northward approvimately 30 to 40 meters to a picket fence.

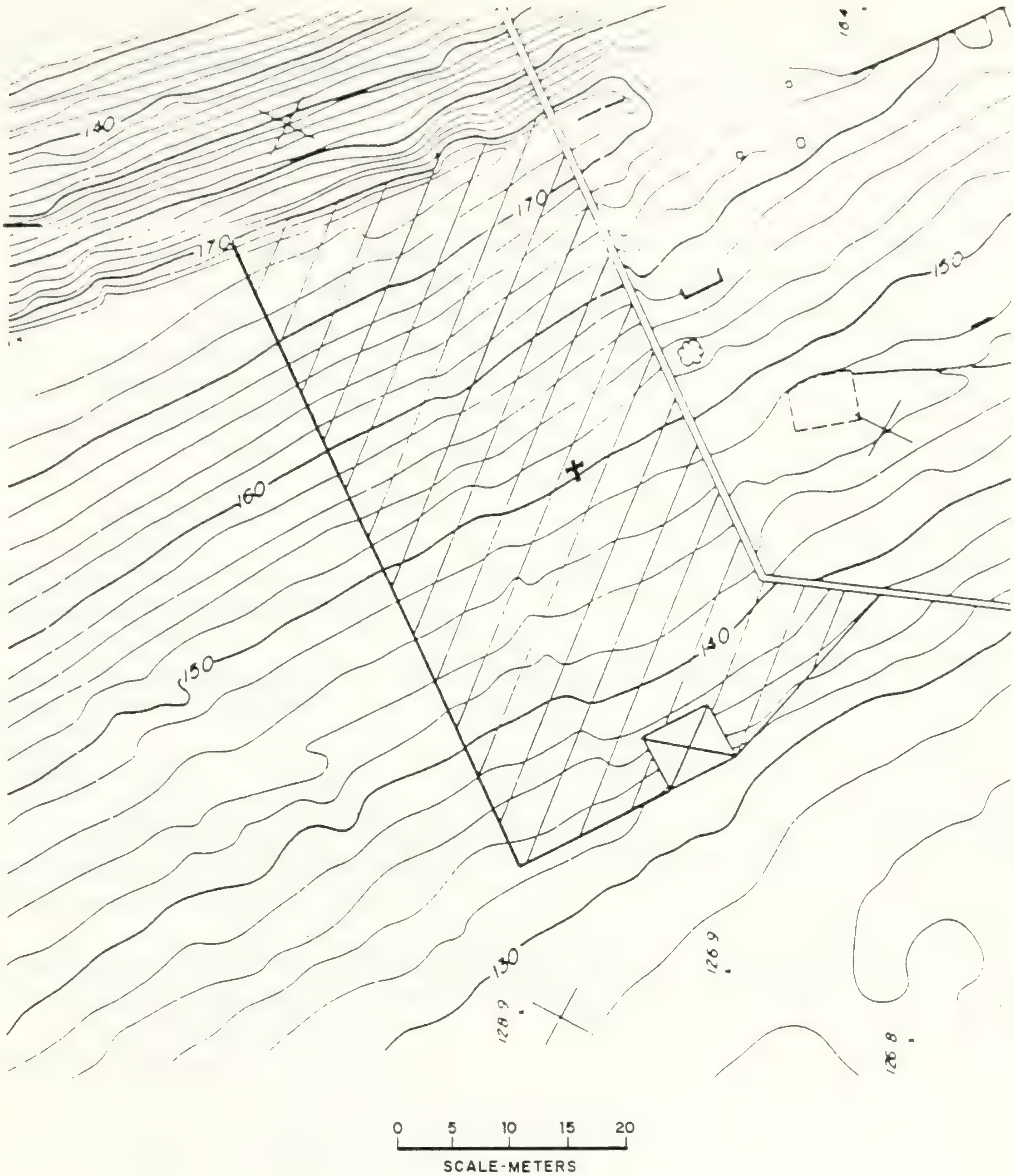
Archaeological fieldwork tended to confirm the smaller cemetery boundaries. Only Trench 1 produced features related to the presence of an historic cemetery within the area examined by the subsurface testing. Trench 2, even though located in a position to cross the cemetery boundary, as indicated on the 1939 and 1940s photos by the white picket fence, did not provide evidence for this boundary. No grave shaft features were located in Trench 2 or in any of the other Trenches 3 through 8. This suggests that the cemetery did not extend more than a short distance beyond the northeast edge of the mausoleum.

Figure P-11 shows the probable revised boundaries of the cemetery based upon the documentary and subsurface testing data. The northwest boundary is an approximation primarily based upon the photographic evidence.

Evidence for the internal configuration and mode of the cemetery was provided by the historic photographs and the locations of Features 1 and 2. The presence of a gridded pattern of wooden crosses in the historic photographs suggest individual graves packed close together. As no evidence has been found suggesting the removal of these burials to another location, it is expected that some 4,252 bodies remain interred in the cemetery. However, it is also possible that crosses marked bodies buried in trenches or in a mass burial.

An attempt to count the number of crosses in the photographs led to another possibility. There were approximately 79 crosses in the area above the mausoleum between the concrete wall and picket fence visible in the 1939 photograph. This correlates closely with the total of 92 bodies buried on Deer Island after 1908. It is possible, therefore, that the burials and crosses correspond to these 92 "new" (1908 to 1946) interments. This leaves the location of the reinterments unclear. Considering the incredibly poor preservation of the wood and bone in Feature 1, and the large, otherwise unexplained anomaly in Blocks 6 and 7, it is possible that the reinterred bodies were buried in a mass grave in this location in 1908. Subsequent burial of the more recent bodies and the intervening 79 years may have erased most evidence of these 4,160 reinterred bodies.

A number of factors may have combined to cause the poor preservation exhibited by the burial in Feature 1 and by the general lack of visible burials. First is the age of the burials, especially the reinterments. The majority of the burials predate 1850. Second, there is no evidence to suggest that any of the bodies were embalmed before burial. Indeed, the 1934 memo indicates that this was not done in the more recent period. Third, it is highly unlikely that the earliest, and therefore the majority, of the burials were interred in coffins. This could tend to detract from preservation potential. Fourth, no information was located concerning the methods used to exhume and then reinter burials in 1908. It is unlikely that great care was



MASSACHUSETTS WATER RESOURCES AUTHORITY	FIGURE P-11 REVISED BOUNDARIES OF NEW REST HAVEN CEMETERY, DEER ISLAND

taken in their transferral. Finally, the cemetery's location on the bluff near the Atlantic ensures the frequent drenching of the plot by salt water and spray during storms and high seas. The corrosive nature of salt water may have contributed to the poor preservation of the burials in New Resthaven Cemetery.

7.1 RECOMMENDATIONS

No further archaeological work is recommended at the New Resthaven Cemetery on Deer Island. Due to the poor preservation of the burials in the cemetery, it is unlikely that burial of the cemetery under a soil beam could cause much further damage than nature appears to have already caused. As no indications of interments were encountered except in the small area above the mausoleum (Figure P-11) construction activities below the mausoleum, below the 148 foot to 150 foot contour lines, are unlikely to cause any disturbance to the cemetery.

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APPENDIX Q

DOCUMENTARY SURVEY OF PRISON SUPERINTENDENT'S HOUSE AND FARMHOUSE

APPENDIX Q

HISTORICAL SURVEY, SUPERINTENDENT'S HOUSE, DEER ISLAND HOUSE OF CORRECTION, BOSTON

This report reviews the history and significance of the Superintendent's House at the Deer Island House of Correction in Boston Harbor. At the time it was described in an earlier document (Boston Affiliates, Inc., Historic Survey of the Deer Island House of Correction and the Deer Island Pumping Station, Deer Island, Massachusetts, October 23, 1985), no documentation for this building had been found. Further research, however, has shown that it originally housed the doctors and other professionals working at Deer Island.

Background

This two-and-a-half storey red brick building was built in 1930-31 to replace the former doctor's residence which had been located in the west wing of the Administration Building. The 1929 fire in the Administration Building destroyed most of the roof of the structure and resulted in extensive water damage. The Commissioner of Construction deemed that only the brick walls and wooden floor joints of the doctor's wing were salvageable. Immediately following the fire, the City appropriated $135,000 for repairs to the Administration Building and the construction of a new building to house doctors. The M.A. Dyer Company, an architecture and engineering firm located at 1 Beacon Street, was selected by Philip A. Chapman, the Penal Institutions Commissioner, as architect for the work.

In February of 1930, the City of Boston under Mayor Curley formally released the funds for the project appropriated by the previous administration. The City allocated $55,000 for the reconstruction of the Administration Building and $80,000 for the construction of the new Doctor's House. A rendering of the house was published on the front page of the City Record (see next page).

Physical Description

Exterior The Doctor's House later became the Superintendent's House, and it is referred to by that name in this report for the sake of clarity. The form of the house represented a significant departure from that of previous construction at the Deer Island House of Correction, which traditionally had a distinctly "institutional" appearance. The Superintendent's House, in contrast, had a domestic quality, resembling a traditional single-family home. It was designed as a multi-functional building, housing not only the doctor, but also the chaplain, cook, and visiting clergy. In addition, the building housed the doctor's office, a library, small chapel, and a storeroom.

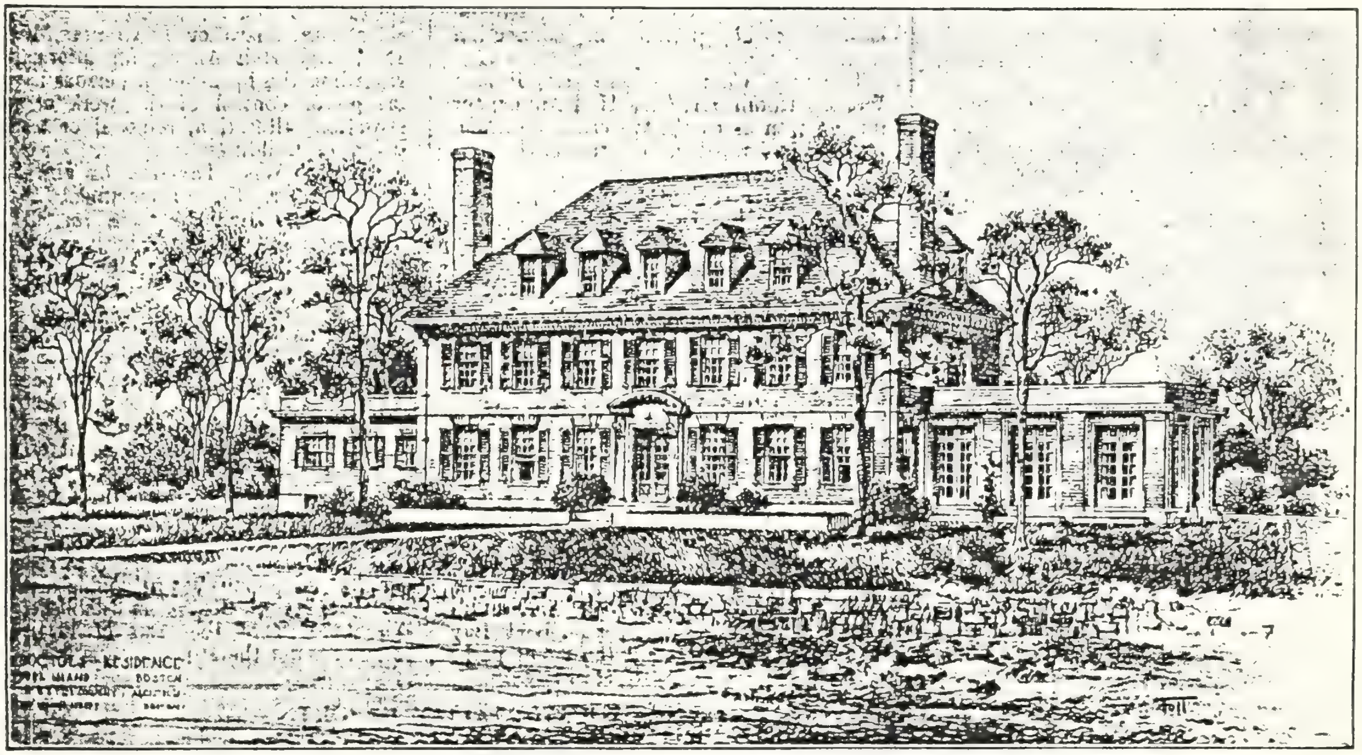
The building is a simple two-and-a-half storey rectangular brick block with a high-pitched slate hip roof and a flat roofed single storey service wing to the side. It is faced in red Flemish bond brick above a cast stone foundation. The main facade is seven bays wide, while

CITY RECORD

Official Chronicle of Boston Municipal Affairs.

Vol. 22. Saturday, February 8, 1930. No. 6

MAYOR CURLEY BEGINS TO COMPLETE $10,000,000 HOSPITALIZATION PLAN FOR CITY INSTITUTIONS INAUGURATED BY HIM IN PREVIOUS ADMINISTRATION — NEW DOCTORS' HOUSE TO BE ERECTED AT DEER ISLAND TO COST ABOUT $80,000 — OLD HOUSE ALSO TO BE RECONSTRUCTED.



ARCHITECTS' PERSPECTIVE OF NEW HOUSE FOR DOCTORS AT DEER ISLAND, TO BE READY FOR OCCUPANCY IN SEPTEMBER.

One of the first steps in the plan of Mayor Curley to complete the $10,000,000 hospitalization plan for city institutions, inaugurated during his previous administration, has been the erection of a new Doctors' House at Deer Island. Bids for the construction of this building have been advertised and it is expected that the contract will be awarded soon. Altogether there will be $135,000 expended. Of this amount, however, $55,000 will be devoted to reconstruction of the old building and the balance, $80,000, will be the cost, approximately, of the new house. It is expected to be ready for occupancy early in September.

In selecting a type of architecture for the new Doctors' Residence at Deer Island, it seemed best to break away from what might be called "Prison Architecture" and to make this building frankly domestic. Situated as it is on our New England coast, one's mind naturally turned, especially in this year of the tercentenary, to the architecture of the Colonies.

In viewing the perspective drawing of the new building, one is impressed with the simple grandeur of the front, which is enhanced by a broad expanse of lawn running to the water's edge. The brick walls are two stories in height with a generous base and fitly crowned with a fine sweep of roof.

The only bit of exterior detail which makes the least pretension of richness is about the doorway, which is flanked by broad, fluted, pilasters surmounted by richly carved Corinthian capitals and crowned by a curved pediment so much used in the architecture of the early periods.

The rest is but plain brick walls, pierced in absolute regularity with windows. To the west is a low wing containing the kitchen, which is balanced by another wing at the east side which contains the sunroom. On the ocean side, the door opens directly into the living room, and the doorway on the similar northern façade opens into a hall, which will have rubber tile floor and a circular stairway depending for its charm on the sweep of the handrail with its slightly tapered mahogany spindles, pleasing in their simplicity and much easier to maintain than painted ones.

(Continued on page 156.)

HOSPITALIZATION PLAN.

(Continued from page 153.)

APPOINTMENTS TO BE COMPLETE.

The northern facade overlooks the present Administration Building and the entrance is back only about forty feet from the main road which traverses the Island. Aside from the hall, the only rooms on this side of the house are the doctors' office, and a library, with washroom beyond. The living room and dining room occupy the entire waterfront, and above them are the rooms of the three permanent residents: the doctor, chaplain, and chief clerk.

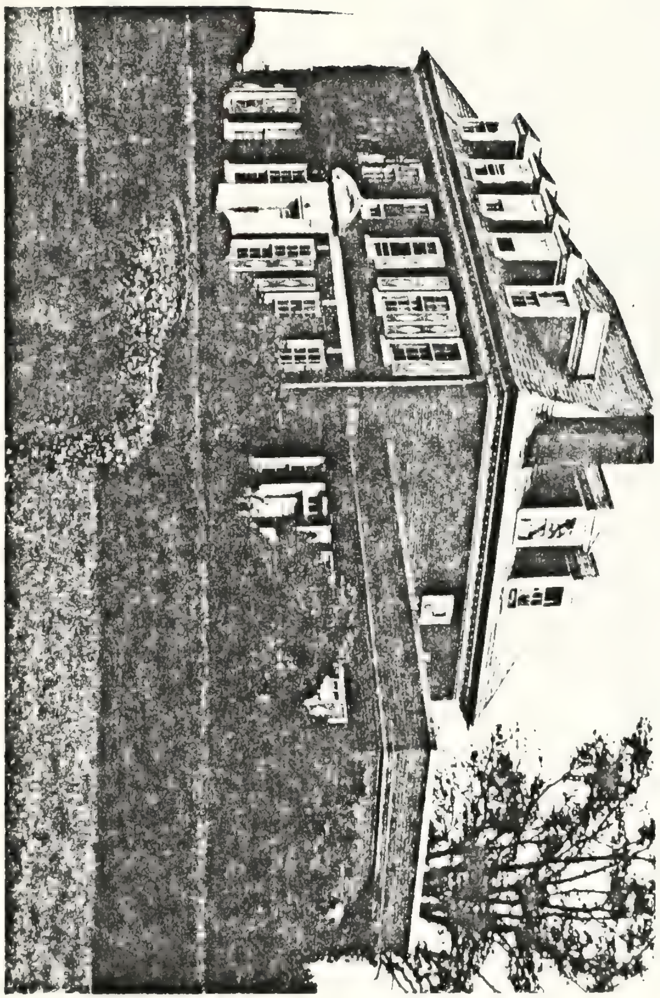
In the northeast corner opening off the vestibule leading to the chaplain's room, is a chapel and a small but compact vestry. In the northwest end there is a linen room opening off the service stairs. Between this and the front hall is an extra bedroom, intended for the assistant physician.

The third floor contains a suite, for the use of visiting clergy, two other bedrooms and a storeroom. All the bedrooms have private baths except two on the third floor, which will use a common bathroom.

The living room and dining room have been made large enough to accommodate official guests and are connected by double doors. There is a fireplace at the end of each room and the walls are paneled with applied wood moldings, except the fireplace end of the living room which is all wood with pilasters flanking the mantle. To the left of this fireplace a door leads to the sunroom with its eight pairs of French doors, which when open really convert the room into a porch. A row of trees to the north will conceal the other buildings on the Island from this room, leaving the open lawn sloping down to the water on the east and south. The dining room is separated from the kitchen by a convenient serving pantry. There is also a small laundry and store pantry in the service wing. The walls and finish throughout, except the stair rail, will be painted.

As the building will be heated from the main plant, there is no basement except a small amount for storage, under the service wing.

It is expected that the new building will be ready for occupancy early in September.



Superintendent's House, Deer Island House of Correction
1985
Photograph by Boston Affiliates, Inc.

the front slope of the roof is punctured with five clipped gabled dormers. The first storey windows are quite tall, being nine over nine lights, topped by cast stone keystones. The second storey windows are somewhat shorter (six over nine) and the dormer windows shorter still at six over six. The first and second storeys are separated by a continuous cast stone stringcourse whose horizontality balances the verticality of the windows. The otherwise planar quality of the walls is relieved by a dentilated cornice and a richly carved door surround composed of Corinthian columns and an overhead segmental arch.

The rear facade is similar to the front, except the ground floor is cut not by windows but by four pairs of French doors opening onto a cast stone terrace. The rear slope of the roof is punctuated by four dormers.

The architect's drawing shows a bilaterally symmetrical facade with east and west wings and chimneys. As actually executed, some of this symmetry is lost. The proposed east wing, a sunroom, was never built, nor was one of the two chimneys. The wing that was constructed (the service wing housing the kitchen) is part of the original design, despite its somewhat modern appearance owing to its flat roof.

Interior

The interior arrangement of the house as executed was similar to that typically found in Georgian homes. The front door opened onto a central hall, with the stairway to the immediate left. Off this hall was the doctor's office and library to the front and the large living and dining rooms facing the ocean. The service wing connected to the dining room and consisted of the kitchen, laundry, and service and store pantries.

On the second floor above the living and dining rooms were the three bedrooms for the doctor, chaplain, the chief, each with its own bath. In the northeast corner, adjacent to the chaplain's room, was the chapel and a small vestry. In the northwest corner were the service stairs, linen room, and an extra bedroom for the assistant physician.

The third floor contained a suite consistsing of two bedrooms and a bath for visitors, as well as a storeroom.

Except for a small storage area under the service wing, the house had no basement. Heat was provided from the main prison plant.

The only interior finishes referred to in the description printed in the City Record are a mahogany stair rail and a rubber tile floor in the hall. There is no evidence that the wood paneling in the living and dining rooms as described in this article was ever installed. Other changes from the original plans were the omission of the sunroom as well as fireplaces for the living and dining rooms, and the construction of a rectilinear staircase in the entrance hall instead of the proposed circular one.

Condition

The Superintendent's House today appears to be in sound though somewhat altered condition. It seems to have been well-maintained and largely unaltered until the 1970's, when its function was changed to housing work-release inmates. During this period, the house suffered considerable wear-and-tear. When the house was converted to office space in 1985 it was completely renovated inside, resulting in the removal of much original building fabric, including windows, doors, and surface treatments, and the introduction of modern elements such as interior windows and fluorescent lighting.

The exterior seems to be relatively unaltered and is in good condition, with the exception of falling copper gutters and downspouts. The greatest visual alterations are the modern vinyl windows. The windows, however, replicate the muntins of the originals, making the change less visually pronounced. In addition, ivy which formerly covered much of the exterior has been removed.

Stylistic Description

The Superintendent's House is a Georgian Revival structure. According to the City Record article, this style was chosen in a conscious effort to move away from the "Prison Architecture" style of the rest of the facility. The Georgian or "Colonial" style was seen as befitting both the coastal New England location of the house while commemorating the Tercentenary of the Commonwealth. Especially at that time, Colonial-style architecture had a great symbolic power, alluding to those qualities believed to be pervasive in that earlier era--independence, morality, patriotism--which seemed to have been lost in a period of economic collapse and social upheaval. This symbolic power made the Georgian Revival a natural choice for public buildings, becoming especially popular in non-urban locations.

Typical of revival style architecture, the Superintendent's House at Deer Island is not a reproduction of any single colonial structure. Rather, it draws from a variety of historical precedents. In overall form, the building is strikingly similar to Westover, a 1730's Virginian plantation house. Its richly articulated segmentally arched doorway, on the other hand, seems based on sources closer to home, especially the doorways of the 1720 MacPhaedris-Warner House in Portsmouth, New Hampshire and the 1750 Royall House in Medford. The greatest departure from authentic Georgian architecture is its somewhat horizontal massing, reflecting a trend in architecture most clearly illustrated by the architecture of Frank Lloyd Wright.

History

The building has been used for a variety of purposes in the half century since its construction. After its initial use as the residence of professional staff at the House of Correction, the building became the Penal Commissioner's residence. The last Commissioner to

reside here was Commissioner Joseph McBrine, who lived here with his family until his retirement until 1972. Subsequent to this date, the house was used as a residence for inmates taking part in the Work-Release program. In 1985, the house was converted for administrative use, housing the Superintendent's and other offices.

Evaluation of Significance

The significance of the Superintendent's House is closely tied to that of the Deer Island House of Correction complex as a whole. The facility is significant primarily for its continued history as an institutional complex accommodating a succession of uses related to social control. The site was developed over a long period of time and many of its structures underwent changes in use as institutional needs changed; the Superintendent's House illustrates this tendency.

The Massachusetts Historical Commission has determined that the Deer Island prison complex does not meet National Register criteria. In a letter to the Regional Administrator of the Environmental Protection Agency (December 6, 1985), the State Historic Preservation Officer stated:

> While individual components of the Prison Complex do retain integrity to their period of significance, the complex as a whole does not, having been altered through the construction of numerous small utility buildings in the 1940's, 1950's and 1960's and through the demolition or substantial alteration of original elements and significant later structures. Components considered to retain integrity to their period of significance and to meet National Register criteria A and C on the local level are the following: Hill Prison (1902-04) ... and The Superintendent's House (ca. 1910).

The information on the Superintendent's House that has come to light, we believe, reduces its significance. In particular, we note the later date of construction than we formerly estimated, the original purpose of the building as a Doctors' rather than the Superintendent's House, and its recent interior alterations.

The Superintendent's House was the last structure at Deer Island to be built with any sort of architectural ambition, all subsequent construction being purely utilitarian in nature. The Doctor's House, however, is a departure from the character of the architecture which preceded it. While the earlier buildings vary widely in style, they share a certain institutional and foreboding quality. The residential character of the Superintendent's House, while it successfully evokes the architecture of colonial residences, is not representative of the architecture of the prison.

The domestic quality of the Superintendent's House may indicate an effort to increase the comfort of important professional employees of the prison, who led a rather austere and isolated existence on the island. The style and setting of the house seems a sort of denial of the nature of the business of the facility. All the private areas of the house face a broad lawn sloping down to the water. Trees were planted in a further effort to minimize the visual

intrusion of the prison. These attempts to house professional employees at a physical and psychological remove from the institutional life of the prison resulted in a building set apart in siting and character from the House of Correction.

As to its historical associations, the construction of the Superintendent's House did represent an ambitious undertaking by the city. The sum of $80,000 for the construction of the house represented a significant public expenditure for the time, roughly one seventh of the prison's total budget for 1930. The public announcement of the project, coming one month after Mayor Curley's third inauguration, was heralded in the City Record as an initial phase of a ten-million-dollar hospitalization plan for city institutions (no mention was made that the funds for the Superintendent's House had already been appropriated under the previous administration). The construction of the Doctor's House was thus a part of Curley's plan to use city-financed construction as a means of getting out of what many perceived would be a short-lived economic slump. An investigation of other city-owned buildings of the period would probably reveal such similar intentions; the Superintendent's House is surely not unique in this regard.

In summary, the Superintendent's House derives what significance it has as a contributing element to the Deer Island complex. Since the complex has been determined to have lost its historic integrity, the house, in our opinion, is of questionable individual significance.

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HISTORICAL SURVEY, FARMHOUSE, DEER ISLAND PUMPING STATION

This report reviews the history and significance of the wood-framed farmhouse located near the original Deer Island Pumping Station. This structure has been variously referred to as a locker building, storehouse, stable, barn and carriage house, attesting to the building's multiple uses over time.

Description

Exterior. The basic form of the farmhouse is a 2 1/2-storey central stable-area with two-storey wings to the north and south. The walls are covered in wood shingles and the roof with asbestos shingles. The central stable area is topped with a gabled roof and a projecting cupola with a hip roof (which once had a flagpole rising from it). An arch is incised into the gable end forming a decorative curve which caps the space above the stable doors. Shingled brackets support the slightly flattened projecting ends of the roof as well as the bottom edge of the projecting curved gable. Both small square and taller rectangular window openings are distributed on each facade in a symmetrical pattern. A canopy which was once over the entrance is now missing.

The north and south wings are each two storeys. The north wing, a barn, has a plain gabled roof, while the south wing's roof has an initial steep pitch which flattens over the porch in the manner of Dutch Colonial farmhouses. Both roofs are punctuated with hip-roofed dormers. The south wing is flush against the stable area while the older north wing is set back from the stable area's facade. The first floor of the south wing has four bays on one facade, each with a rectangular window. The facade along the other side has a projecting sun porch under the shallow pitch of the roof. On the first level, the north wing has two large barn or garage doors placed side by side, with a rectangular window opening to the north.

The gable ends of each of these wings have a set of paired windows below the peak of the gable. The south wing is also topped by a small chimney.

Interior. The north wing is apparently the oldest part of the structure. It was once a simple rectangular barn, two storeys tall. The dormers were added later and the roof extended to meet the slope of the central stable area. A loft door and hoisting beam are at the north end. The concrete slab floor at ground level was added later.

The central stable area consists of two floors and an attic with a ventilator (cupola). Wooden posts that once supported the second floor have been removed and replaced by a queen post truss. The shingled exterior wall of the original building is visible at both the first and second floor levels. A wooden stairway leads up to the second floor and attic and a trap door on the center of the second floor would have been used when the building was functioning as a stable. Vestiges of two electrical systems, one from the 1930's (knob and tube), and the other more recent (BX cables), were found. The flooring on the first level is earth.

Farmhouse, Deer Island, 1985
Photograph by Boston Affiliates, Inc.

The south wing was used as a dwelling unit, perhaps for the superintendent of the treatment plant. The first floor has a living room, dining room, kitchen and parlor, and is entered through a sun porch. The second floor has bedrooms and a bathroom. A door goes through to the central or stable area on each floor. The walls are plastered, with the plaster applied to both machine cut lath and wallboard. There is a crawl-space under this wing, accessible through an opening in the brick foundation. The electrical system is similar to that of the central stable-area. The interior detailing includes wood moldings around the doorways and matchboarding in the bathroom.

Condition

The farmhouse has been used for some years by the MDC for the storage of old tires, sand, and old documents. While the frame is generally intact, the building is open and exposed to the elements, and is seriously dilapidated. The windows are missing and there are holes in the roof. Large sections of plaster in the south (residence) wing are missing. There is vegetation pressing up against the house and growing in the wooden gutters and crevices of the roof. There are no interior fixtures, and the floor of the sun porch is rotted through.

Site History

The Deer Island property was acquired by the Metropolitan Sewerage District Commission from the City of Boston between 1889 and 1895. The M.D.C., established in 1889, was the first regional sewerage system in the country. By 1896, the Pumping Station at Deer Island had been built and was operating. It was the largest of three stations constructed at the time to pump sewage through the North Metropolitan system.

Just to the south of the Pumping Station and north of the Farmhouse, the Sewerage Commission built a dwelling house for employees, designed by Boston architect Ernest Boyden. Constructed from 1896 to 1897, and since demolished, the large wood-framed shingled house held four separate apartments. With its wrap-around veranda and hipped roof, it showed the architect's graceful interpretation of contemporary design ideas. Its design, massing, and materials reflected the pervasive influence of the Shingle Style and the Colonial Revival.

The Shingle Style is an American style of domestic architecture influenced initially by the Old English architecture of Richard Norman Shaw. The style, which reached the height of its popularity in the 1880's, was most often used for seaside and countryside homes. Named for its use of cedar shingles which form a skin over the rounded contours that typify the style, Shingle Style houses generally are massed low to the ground on heavy stone foundations. While Colonial motifs appear as isolated elements (such as broad gables and small window panes), the Shingle Style is largely a non-historical style, its form based on an attempt to create homes which appear to grow out of their natural surroundings.

While this house no longer exists, the Farmhouse just to its south along the coastline still stands, though in a dilapidated state. The link between the farmhouse and the dwelling house

appears to be strong. Both were closely associated with the employees of the Pumping Station and both were designed using a similar architectural vocabulary. While the workers lived in the dwelling house, the M.D.C.'s use of the Farmhouse is less clear. At various times in its history, it apparently used the Farmhouse as a locker building, garage, toolroom, stable, and storeroom, as well as an additional apartment. Physical evidence indicates that the Farmhouse building, which consists of a stable-like area and two wings, was originally a simple rectangular two-story barn. This original building was incorporated into a larger structure and became the north-side wing. Like the dwelling house, the Farmhouse is covered with an exterior skin of wooden shingles that indicates deliberate stylistic connections between the two buildings.

Building History

While all available materials and sources have been consulted, no definitive account of the history of the Farmhouse was found. Rather, a history of the activities pertaining to the building can be combined with evidence found from visual inspection to form a general indication of the date, uses and significance of this building.

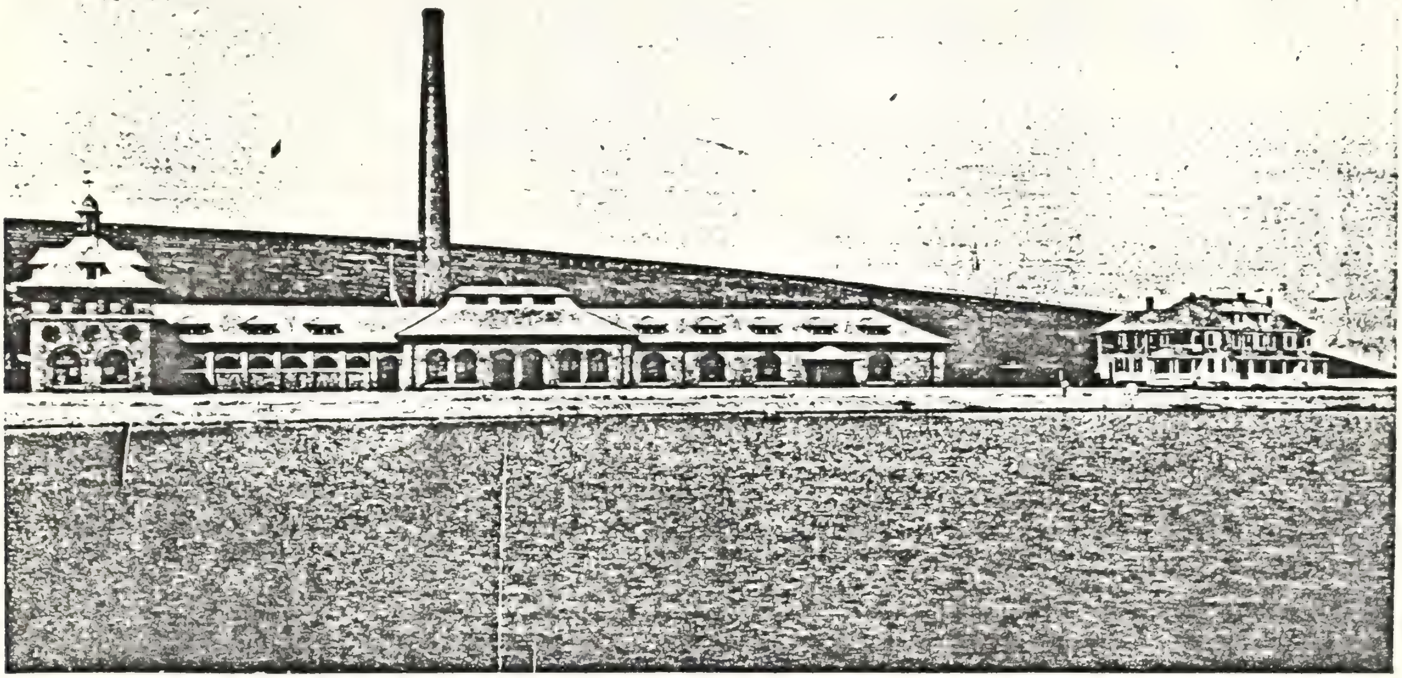
The first documented reference to the Farmhouse dates from 1919 when the maintenance report for Deer Island in the Metropolitan Sewerage Commission's Annual Report mentioned that the dwelling house and "locker building" were repainted. The next year (1920), steam heat and electric lights were installed in "the storehouse and stable." A 1923 map shows the farmhouse and describes it as a "locker."

In 1929 this locker building received an addition. However, from visual inspection it is not likely that any major portion of the building dates from that time. The previously-mentioned 1923 map had already depicted the locker building as a tripartite structure, indicating that later additions were small. The central stable area and south wing were most likely added to the original north wing around the turn of the century. The north wing itself probably dates from the last quarter of the nineteenth century.

The south wing was used as a "tenement," and in 1935 the residence was renovated and re-wired, in preparation for occupancy by one of the Pumping Station engineers.

In the following year (1936), the concrete floor in the north wing was installed. At that time the building was "pulled into line and plumbed and boarded," while a new concrete foundation was set, augmenting the original badly-settled brick foundation. Interior posts and studding for a partition were also in place. These repairs were all done on what is referred to as the "north ell of the barn," meaning original north wing.

By 1937, the general repairs made "at the barn" included the new foundations, asphalt roofing and repainting. These renovations provided expanded uses for the building, including, "a locker room for the maintenance men, a toolroom, and a garage for the truck." The last reference to "the barn" in these maintenance reports came in 1938 when it was reshingled.



DEER ISLAND PUMPING STATION. DWELLING HOUSE FOR EMPLOYEES.

From: Annual Report of the Metropolitan Sewerage Commission, 1897

Looking S'ly from sta. 12+00 - Showing future location
of Chamber B - Deer Island Outfall - Cont. 273 -
7/17/59 - Photo Harbler - 273-7

From: Metropolitan District Commission Archives

At some point the grand shingled dwelling house nearby was razed, signaling the end of an era when employees of the Pumping Station, engineers and laborers, lived in isolated houses on an island accessible only by water. The construction of the causeway connecting Winthrop to Deer Island through the Shirley Gut in 1940 made it unnecessary for employees to live on Deer Island. In 1974 the Pumping Station was decommissioned. By 1986 the Farmhouse was not being used as a toolroom, lockerroom, garage, or residence, but instead as a storage area by the MDC.

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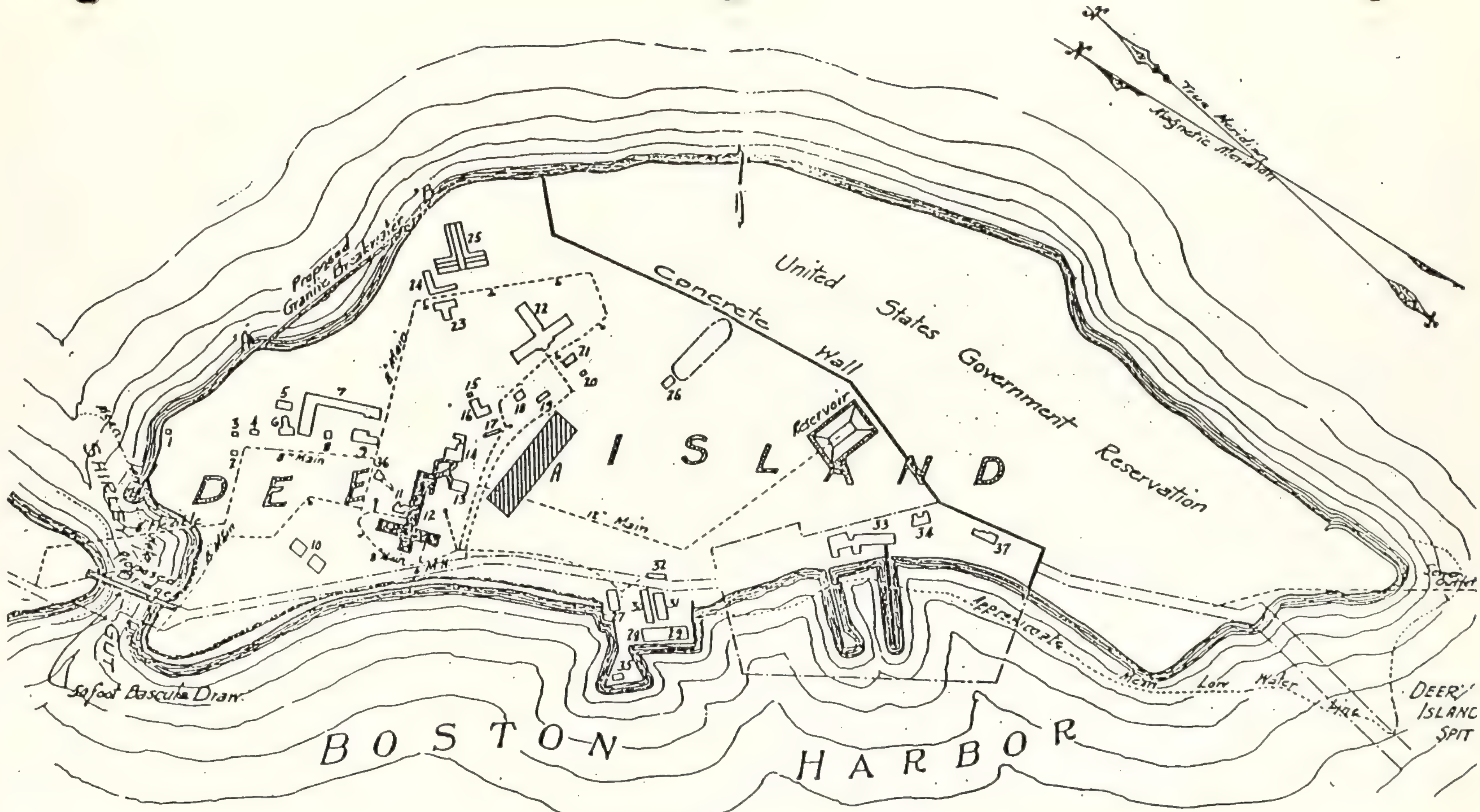


No.	Description of Building	No.	Description of Building	No	Description of Building
1	Boat House	14	School House.	27	Receiving Room
2	Morgue	15	Hen House	28	Stone Shed
3	Boat House	16	Cow Barn	29	Coal Shed
4	Storehouse	17	Ensilage Building	30	Stone Shed
5	Power House	18	Farm House	31	Stone Shed
6	Carpenter, Paint + Shoe Shop	19	Greenhouse	32	Blacksmith Shop
7	Barracks "B"	20	Hill Fire Room	33	Metropolitan Power House
8	Deputies House	21	Laundry	34	Engineer's House
9	Bake House	22	Women's Prison	35	Wharf House
10	Hospital	23	Horse Barn	36	Fire Station
11	Boiler Rm. + Machine Shop	24	Wagon Shed	37	Locker
12	Old Prison	25	Piggery	A	Proposed Industrial Building
13	Store	26	Ice House		

Plan to accompany Report of Special Commission appointed under Chapter 62, Resolves of 1923, relative to the Relocation of the State Prison.

Scale of feet.

0 100 200 300 400 800 1200 1600

Note:-

Buildings, Existing shown thus.
Buildings, to be Remodelled ..
Buildings, New Construction . - ....

APPENDIX R

EVALUATION OF THE ENGINEERING FEATURES AT THE DEER ISLAND SEWERAGE WORKS 1894-1909

EVALUATION OF THE ENGINEERING FEATURES AT THE DEER ISLAND SEWERAGE WORKS - 1894-1909, BOSTON, SUFFOLK COUNTY, MASSACHUSETTS

Prepared for:

Boston Affiliates
156 Milk Street
Boston, Massachusetts

Prepared by:

Jeffrey C. Howry, Ph.D.

November 22, 1987

TABLE OF CONTENTS

Preface

A previous historic survey report prepared by Boston Affiliates (October, 1985) considered the general historic significance of various facilities located on Deer Island, among them the pumping station located on the southwest side of the island. The purpose of this report is to evaluate the historic significance of the engineering feattures of the sewerage works constructed on Deer Island, and to make recommendations concerning the appropriate treatment of the historic resources.

1.0 Overview of the Metropolitan Sewerage System

1.1 Background to the Regional Sewerage System

The general plan of a Boston-area system was proposed by a commission convened in 1875, whose members were of E.S. Chesborough, Moses Lane and Dr. Charles F. Folsom. The "Chesborough Commission" (named after its most eminent member, a civil engineer involved in the design of the Boston water system in previous decades) produced recommendations which initially resulted in the design of the Boston Main Drainage. The Boston system commenced construction in 1877 with an end point on Moon Island, and was designed with the intent of releasing accumulated sewage at periods of receding tide.

1.2 The Metropolitan District Sewerage Commission

The Board of Metropolitan Sewerage Commissioners was organized in 1889 by an act of the Massachusetts legislature for the purpose of directing the design and construction of a metropolitan sewerage system to serve towns to the west and north of Boston. The Metropolitan System comprised two separate systems. The Charles River system connected portions of western Boston, Brookline, Newton, Waltham and Watertown to the Boston Main Drainage. The North Metropolitan system linked 14 communities north and west of Boston proper, from Winthrop and East Boston to Winchester and Woburn. Pumping facilities related to the North Metropolitan Sewerage System were located in East Boston, Charlestown and North Somerville, all of which served as low-lift stations for principal branches that supplied a main gravity line that terminated at the Deer Island Sewerage Works. At the Deer Island facility sewage was pumped continuously into the harbor via a submerged conduit whose outlet was near the Deer Island Light. The North Metropolitan system represented approximately 85% of the Metropolitan Sewerage system's capacity, based upon total population served at the time of its design.

The Commissioners appointed Howard A. Carson as Chief Engineer in October, 1889, in charge of directing the survey, design construction of the entire Metropolitan Sewerage System during the years that followed. By 1895 William M. Brown, Jr. had succeeded Mr. Carson, who left to assume the position of Chief Engineer for the Boston Transit Commission at a time when the street railways were being consolidated into a single company.

2.0 Deer Island Sewerage Works

The Deer Island facilities were initially completed during the years 1894 to 1895. The facilities included the following structures:

> Pumping Station - containing an engine room, boiler room with economizer and a 125' high stack, coal house and screening house,
>
> Coal Wharf - connecting to the coal house section of the pumping station by a coal-run more than 400 feet in length,
>
> Trestle with intake and discharge pipe - for seawater to serve as cooling water for the low pressure piston of each steam engine,
>
> Residence - containing four units and located about 150 feet south of the pumping station,
>
> Masonry outlet conduit connecting to a submerged wooden conduit terminating at Deer Island Light.

The tenement dwelling was apparently removed some time after 1939, as it is indicated on plans as of that date. Only the pilings remain of the coal wharf, and no portion of the coal run is extant. A coal car (see photo in Addenda) remains near the pumping station, suggesting that coal was transferred by a system of small shuttle cars that moved over narrow-gauge rails between the wharf and coal house.

An overall layout of the facilities is illustrated in Figure 1. The pumping station buildings were designed by Boston architect Arthur F. Grey; general contractors were Gooch & Pray, also of Boston; the contractor for the pumping plant was the Edward P. Allis Company of Milwaukee, Wisconsin.

A building south of the residence, and identified as the 'Farmhouse' in the previous Boston Affiliates report, was constructed approximately 1,000 feet south of the pumping station. The structure is a two-story, double-wing building that may have served as a residence as well as had administration functions. Its design suggests it was constructed during the same period as the two construction phases of the pumping station discussed in this report.

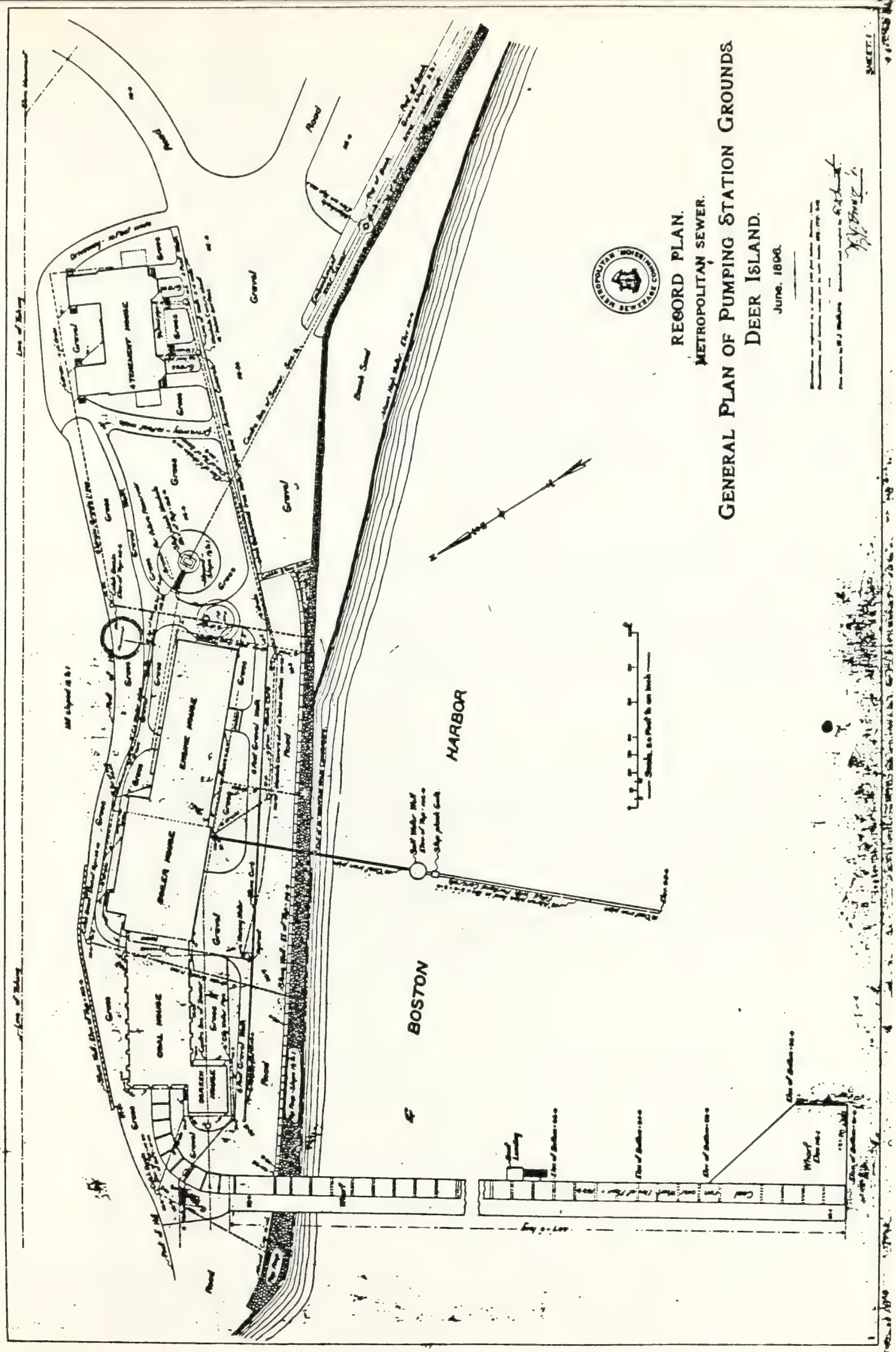


Figure 1 - Plan of the Deer Island Sewerage Works (1896)

2.1 Pumping Station

The building segments comprising the pumping station were constructed with a granite foundation, brick walls and hipped slate roofs with terra-cotta coping along the roof ridges and gables. Interior floors are brick pavers or terra-cotta tiles in the engine rooms and concrete in the remaining areas of the pumping station. The different segments could be considered as having three functional components - screening room, coal house and boiler room, and engine room. Each building segment shares at least one common wall with an adjacent room. The original engine room (100' x 31.5') and boiler room (65' x 35') were completed in 1894, followed by the coal house, the two-story screen house and the coal-run in the latter part of 1895.

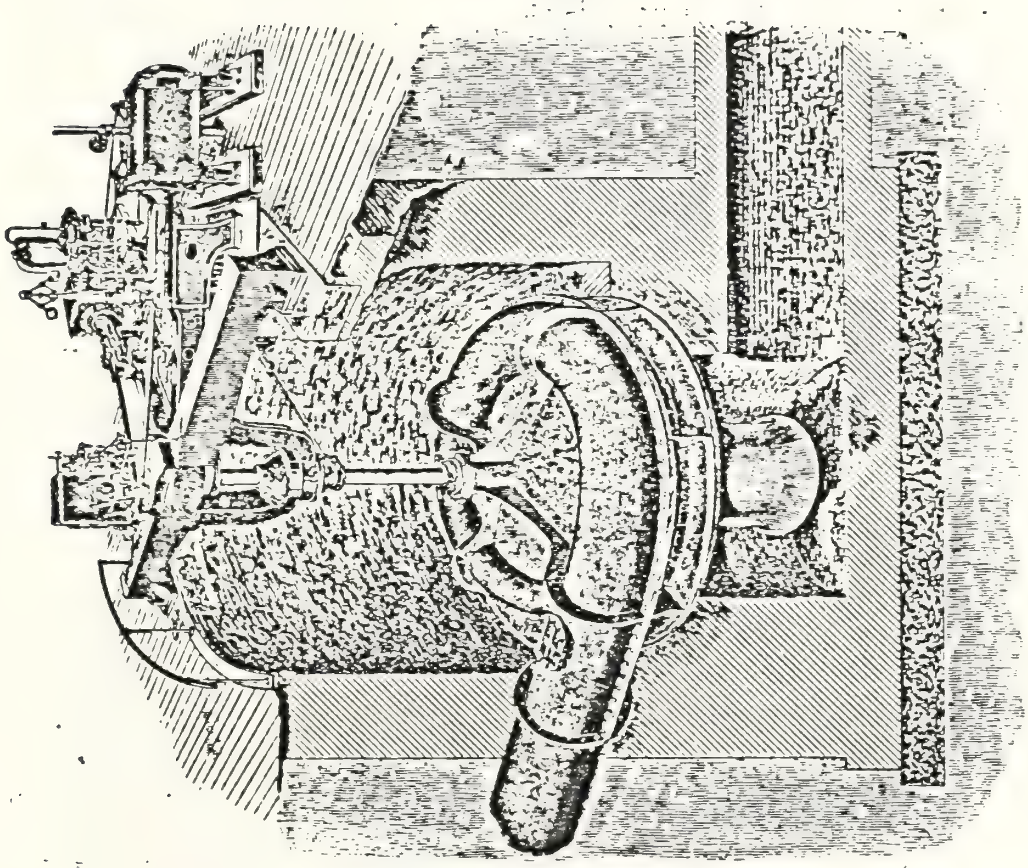
The operation of the pumping station involved first passing the incoming sewage from the gravity sewer conduit through a screening apparatus to remove large debris and insoluble organic matter. After screening, the sewage passed to the centrifugal pumps where it was lifted an average of 12 feet to the discharge channel and out into the harbor through a specially constructed wood-stave conduit submerged for a length of 1,925 feet from the end of Deer Island to a point opposite Deer Island Light.

2.2 Screening Machinery

The screening apparatus comprised two separate but similar pieces of equipment that contain a series of vertical screens of steel bars suspended above the incoming sewer conduit by a chain-driven hoisting system powered by small steam engines (see photographs and plans in Addenda). The two-story structure on the northwest corner of the present pumping station was the original Screen House completed in 1895. With the expansion of the station in 1909, an additional screening apparatus was added behind the original building as part of the coal house addition.

2.3 Pumps and Steam Engines

The original configuration in the engine room of the pumping station allowed for three centrifugal pumps with impellers 8.25 feet in diameter, each driven by a horizontal, triple-expansion steam engine of the Reynolds-Corliss type. The engine and pump combination was a specially manufactured design of the Edward P. Allis Company, Milwaukee, Wisconsin intended to pump high volumes of sewage with a relatively low lift (see Figures 2 and 3). At the Deer Island facility each of the pumps was rated at 45 million gallons a day with an average lift of 12 feet. Records for the period of 1898-1899 indicate that during times of high rainfall, daily pumping exceeded 86 million gallons (Eleventh Annual Report, p.21). The original Reynolds-Corliss engines incorporated three cylinders with diameters of 13.5", 24" and 34" set at 60 degree angles in order to provide



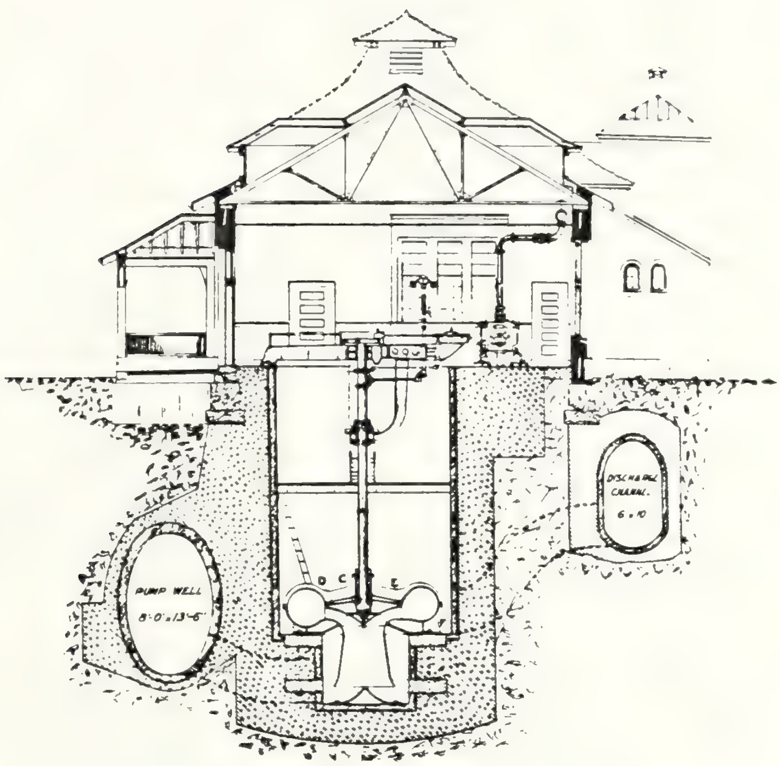
CENTRIFUGAL PUMP.

"BOSTON TYPE."

FIGURE 2

Source: E.P. Allis Catalogue ca. 1898

PLATE A



SECTION THROUGH PUMP.
DEER ISLAND STATION.

SCALE OF FEET

FIGURE 3

Source: Annual Report for 1897, Metropolitan Sewer Commission

uniform rotation to the pump crank shaft. The design allowed steam to pass from the first cylinder to the second, and finally onto the third. As the steam passed to successively larger cylinders, it expanded, thereby providing additional energy at each step before being removed from the engine.

The two initial engines and pumps installed in the plant were operational by 1896, and in regular service by 1897. In May, 1900 a third engine and pump was placed in service identical to the two original engines and pumps. The profile plan of the pump and engine in Figure 2 is taken from the E.P. Allis Company catalog ca. 1898, and illustrates the arrangement of the two components in a pump pit, as is found at the Deer Island facility. During that same year, an additional pump pit was excavated at the south end of the original engine room in order to allow for the addition of a fourth engine and pump. Dimensions published for the fourth pump excavation indicate that the pit is at least two feet larger than that of the earlier pumps. During the period of 1909-10 a two-story brick addition was completed at the southeast end of the engine room, and a 100 million gallon-a-day pump was installed by the Allis-Chalmers company with an engine of the same triple expansion type but of larger dimensions than those previously installed (note: documentation for the later building additions is less detailed than that of the initial construction; specific dimensions were not published in the reports describing the pumping station expansion). Additions were also made to the screening machinery, boilers and coal house (see below).

The installation of diesel engines in the 1950's resulted in the removal of the three original steam engines. However, the original centrifugal pumps likely remain in the pump pits. Only the block of a single diesel engine remains at the middle of the three original pumps. The fourth steam engine and pump, the original Reynolds-Corliss equipment installed in 1909 by the Allis-Chalmers Company, remains over a centrifugal pump in the southeast addition to the engine room.

2.4 Boilers and Economizer

The boiler house has three pairs of boilers, two pairs of which were installed when the facility was initially constructed in 1895. All are of the horizontal return-tubular type, and are attached to a Green fuel economizer. The initial two pairs of boilers were supplied by Edward Kendall & Sons, of Cambridge, Massachusetts. The economizer was provided by the Fuel Economizer Company of Matteawan, New York. [An economizer is a heat recovery device that allows for the capture of waste heat in the boiler flue that is used to preheat water entering the boilers for the production of steam.] The original boilers installed in 1895 were supplemented by a larger pair of boilers that were added in the expansion of 1909.

2.5 Coal House

The original coal house was designed with large dimension wooden timber framing that supported and reinforced concrete walls. As part of expanding the facility's capacity in 1909, a rear addition was made to the coal house that exceeded the storage capacity of the original coal house. The addition also provided for the construction of a second screen room adjacent to the original screen house (see plans in Addenda).

2.6 Related Features

There are three engineering structures apart from the pumping station building which are important components of the Deer Island Sewerage Works: the outfall conduit, the coal wharf and the seawater intake and discharge pipe.

The original coal wharf with trestle constructed for the pumping station extended 407 feet southwesterly from a point in front of the screen house. At the screen house the trestle curved toward the building making a 90 degree turn into the side of the coal house. Limited available evidence suggests that small coal cars running along narrow gauge rails on the trestle transported coal from barges or other supply vessels to the coal house. When the addition was made to the coal house in 1909, an extension was constructed extending the trestle to the side of the new coal house (see plans in Addenda for details on wharf and trestle location).

The outlet conduit south of the pumping station was constructed by the coffer dam method until reaching deep water where the conduit was extended by specially constructed sections of wooden pipe of reinforced oak hoops lined with portland cement. The pipe sections were 52 feet long, 6 feet 3 inches in diameter, and weighed up to 210,000 pounds. After their construction on land, each section was towed out to its proper location. A specially constructed floating cradle was designed which lowered the sections into a dredged trench after each section was partially flooded. Sections were then connected under water by divers. The total length of the outlet conduit was 1,925 feet, extending from a point approximately 60 feet inside high water line to a point opposite the Deer Island Light.

A pair of sea water intake and discharge pipes of cast iron enclosed and supported by a wood trestle were constructed perpendicular to the boiler house. The trestle extended several hundred feet from the shore, and included a sea water well at approximately the mid-point of its overall length.

3.0 Significance and Integrity of the Engineering Features and related features of the Deer Island Sewerage Works

3.1 General Significance

The Metropolitan Sewerage District was a concept developed in part by E.S. Chesborough, a distinguished American civil engineer of the nineteenth century and an important contributor to the design of the Boston metropolitan water supply system. The Metropolitan Sewerage System is among the engineer's later contributions to the Boston area.

The Boston area, at the initiative of the State Board of Health, became the first urban area in the U.S. to develop an extensive system of intercepting sewers connecting adjacent municipalities in order to collectively manage sewage disposal and to also provide an interconnected water supply, as well (Stott, 1984). The Deer Island Sewerage Works represents one of the few remaining late nineteenth and early twentieth century facilities of its kind which preserves both historically important engineering features and distinctive architecture. The property is most significant for its engineering features which demonstrate a system of handling large quantities of sewage as part of managing a major urban public health issue. The specialized machinery present represents a combination of components that demonstrate technology important to the urban development of many American cities, and particularly so because of the wider use of the technology first used in the Boston system and applied to other urban sewerage systems.

The pumps and engines were developed and installed by the Edward P. Allis Company, a nationally recognized machinery manufacturer during the nineteenth century. The company's chief engineer and designer of equipment, Edwin Reynolds, was among the most distinguished mechanical engineers of large steam machinery prior to the introduction of the steam turbine. The particular equipment used at the Deer Island facility represents the first use of a design which was later duplicated and sold to other municipal governments in the U.S., among them New Orleans, Chicago and Milwaukee. The particular horizontal configuration of the engine and pump are an unusual solution to the problem of pumping at varying speeds, and particularly slower speeds, without loosing the necessary suction to lift liquids.

3.2 Integrity and Significance of Remaining Engineering Features

The integrity of certain historic components of the Deer Island Sewerage Works has been jeopardized or entirely lost as a result of selective removal of certain machinery, vandalism and general physical deterioration. The coal wharf remains only as a series of wooden piles extending out from the shoreline. The three earliest steam engines were removed in the 1950's when diesel engines were

installed. When the pumping station was taken out of service in 1968, limited, if any, physical repair of the building was performed except to discourage vandalism. As a result, substantial roof damage has occurred and water continually penetrates sections of the building.

Available documentation and preliminary inspection of the Deer Island Sewerage Works indicates that the following engineering components and related features remain at the property:

1. Three centrifugal pumps, each with a daily capacity of 45 million gallons,

2. A 100 million gallon centrifugal pump connected to a horizontal, triple-expansion steam engine (most which remains in place),

3. Two sewage screening machines, with many gears and the small steam engines used to operate the lifting apparatus removed,

4. Boilers, economizer and 125 foot stack,

5. Sea water intake and discharge trestle with pipe,

6. Wooden discharge conduit extending to Deer Island Light (installed 1895-96 and presumed buried below present harbor bottom).

In spite of the water penetration, the steel and heavy timber framework of the pumping station continues to support the roof and walls of the individual sections within the overall structure.

3.3 Summary

The Deer Island Sewerage Works (1894 - 1909) retains many historic engineering and architectural features which support its eligibility for the National Register of Historic Places. The property is important as an early manifestation of regional planning for public health and safety. The property is a central component of a larger system which was conceived and designed by individuals of national and regional importance. The property retains components of exceptional value to the history of mechanical engineering, and particularly, the application of steam technology to hydraulic engineering. The existing 100 million gallon-a-day centrifugal pump is possibly the largest of its type ever manufactured, and is the only remaining example of its size in the U.S. (the two similar engines and pumps at the East Boston Pumping Station are rated at 45 million gallons a day).

4.0 Recommendations

4.1 General Recommendations

The historic significance of the Deer Island Sewerage Works (1894 - 1909) in large measure is a result of its possessing many of the related components that are integral to a historic site of its type. The design of the pumping station principally reflects the functional needs of the equipment intended to serve a special use, namely, for pumping sewage. The special qualities of the historic pumping station and related facilities warrant their preservation in place as the preferred method of treating the resource. If the components of the sewerage works and its principal building can not be preserved in place, relocation of its principal engineering components should be undertaken. The special examples of technology represented by the pumping engine, centrifugal pumps, screening machinery and associated technology represent historically significant examples worthy of preservation and restoration.

4.2 Record Documentation

Prior to undertaking any building rehabiliation activities, site clean-up, removal of structures or the relocation of equipment from the pumping station and surrounding area, it is important to record the location and types of equipment or features now existing at the property. The most cost-effective method initially is to undertake the photographic documentation of all engineering and architectural features. Following the photographic documentation, other types of record documentation should be prepared:

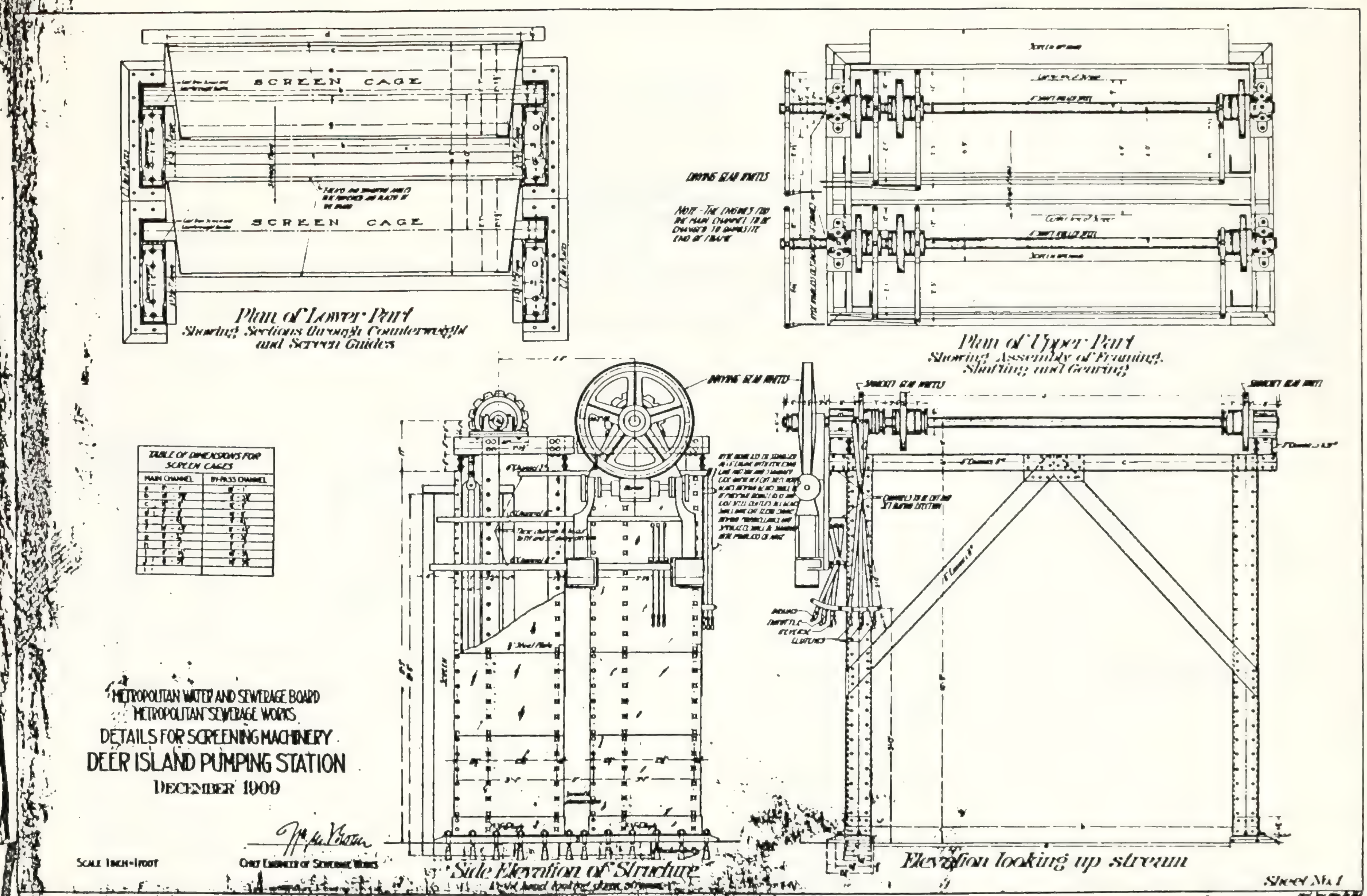
- copies of existing building plans (e.g. the 1896 record plans and additions) should be made on archivally stable materials such as mylar or large format film (8x10 inches);

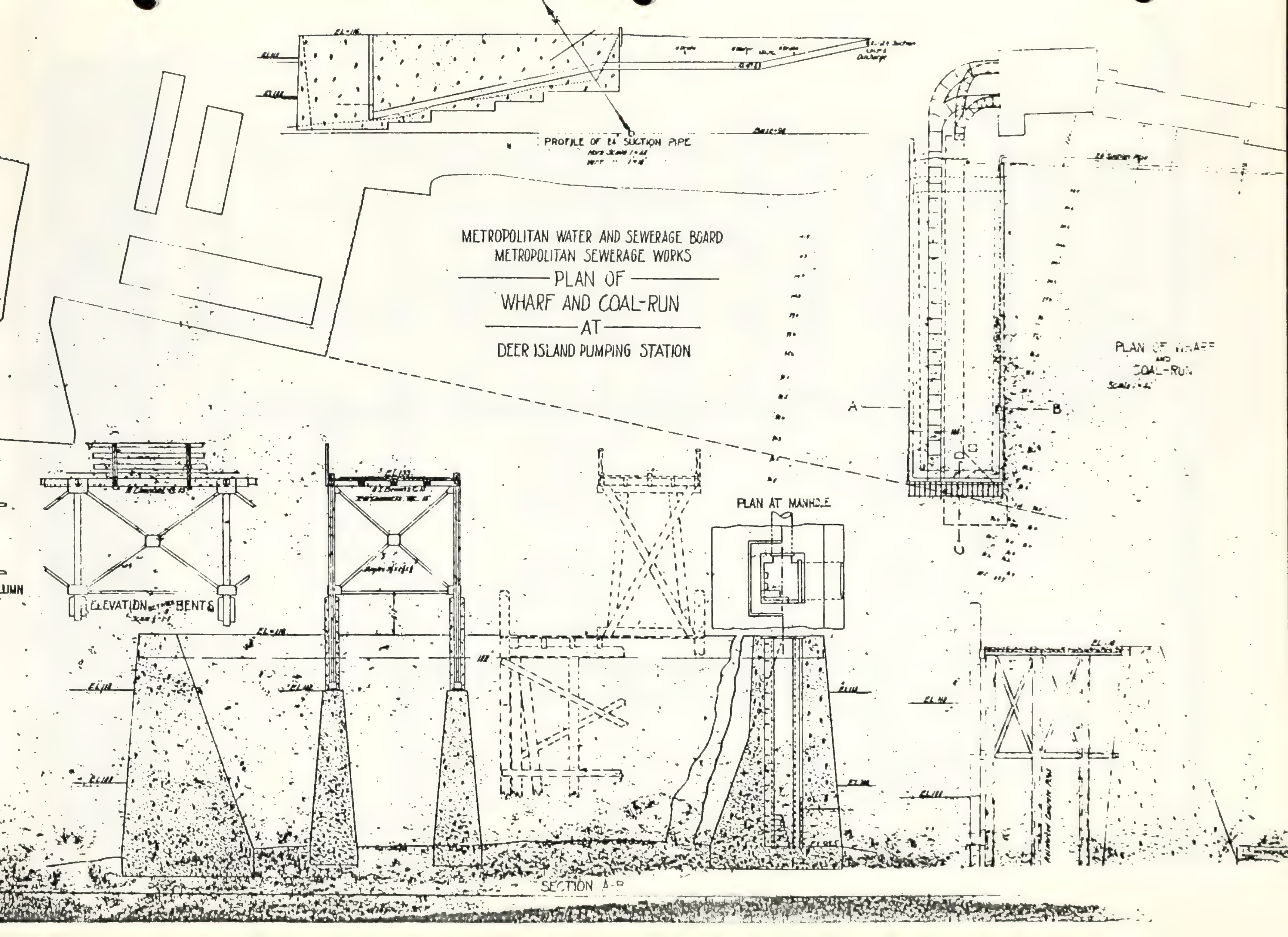
- a detailed site history documenting the various building phases and improvements made to the facilities over the past 90 years.

4.3 Building Re-use Considerations

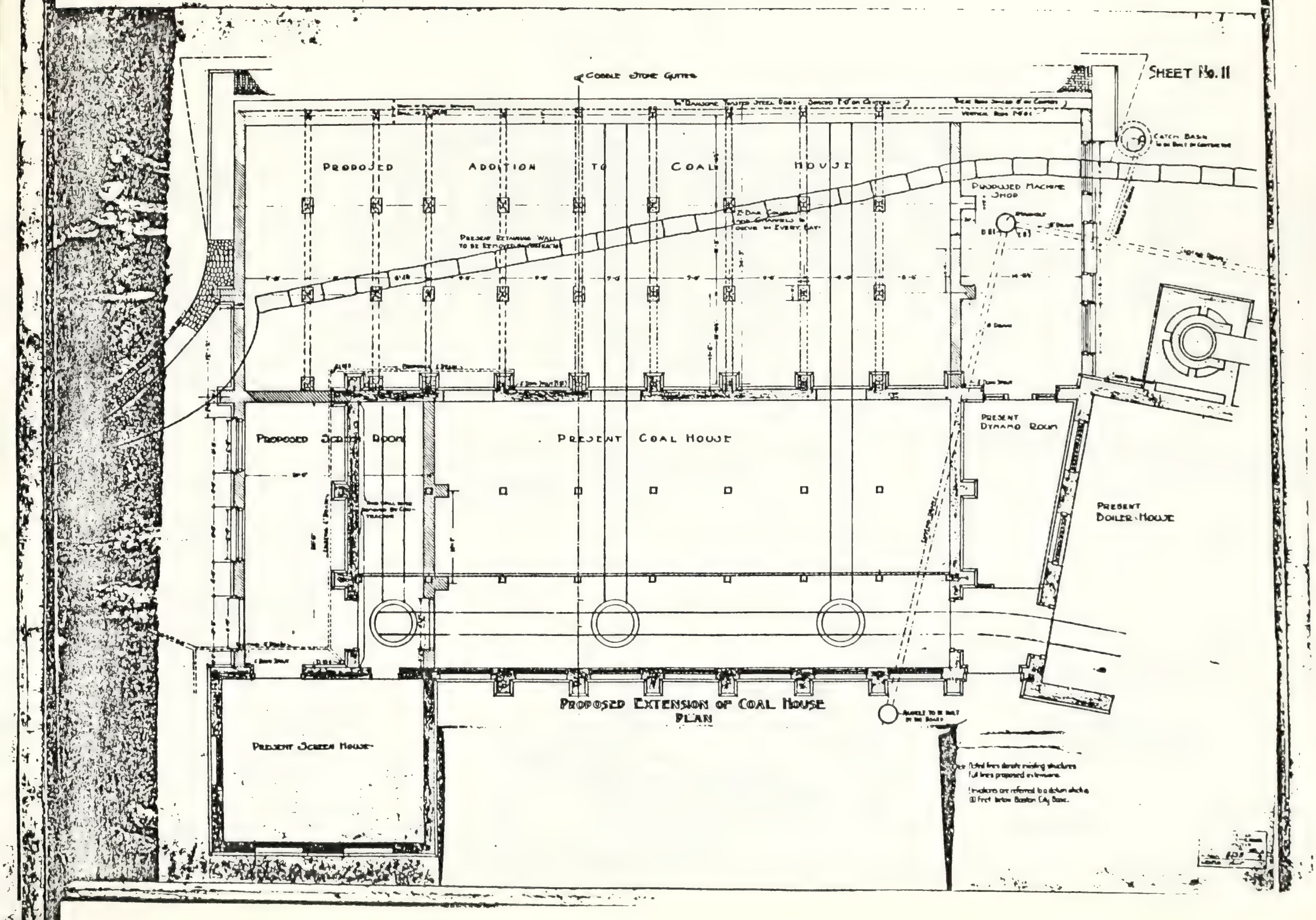
Future use of the pumping station will require investigation of the condition of various control valves that formerly were designed to handle the incoming and outgoing sewage. Conduits passing under the building connect directly to the centrifugal pumps below the pump wells accessible from the engine room floor. Control of groundwater penetration into the abandoned sewage conduits will likely be necessary in order to insure that adequately dry conditions prevail for re-use of the building. The present flooding of pump well No. 3, for example, may be the result of a failure of a control valve leading to the pump.

ADDENDA

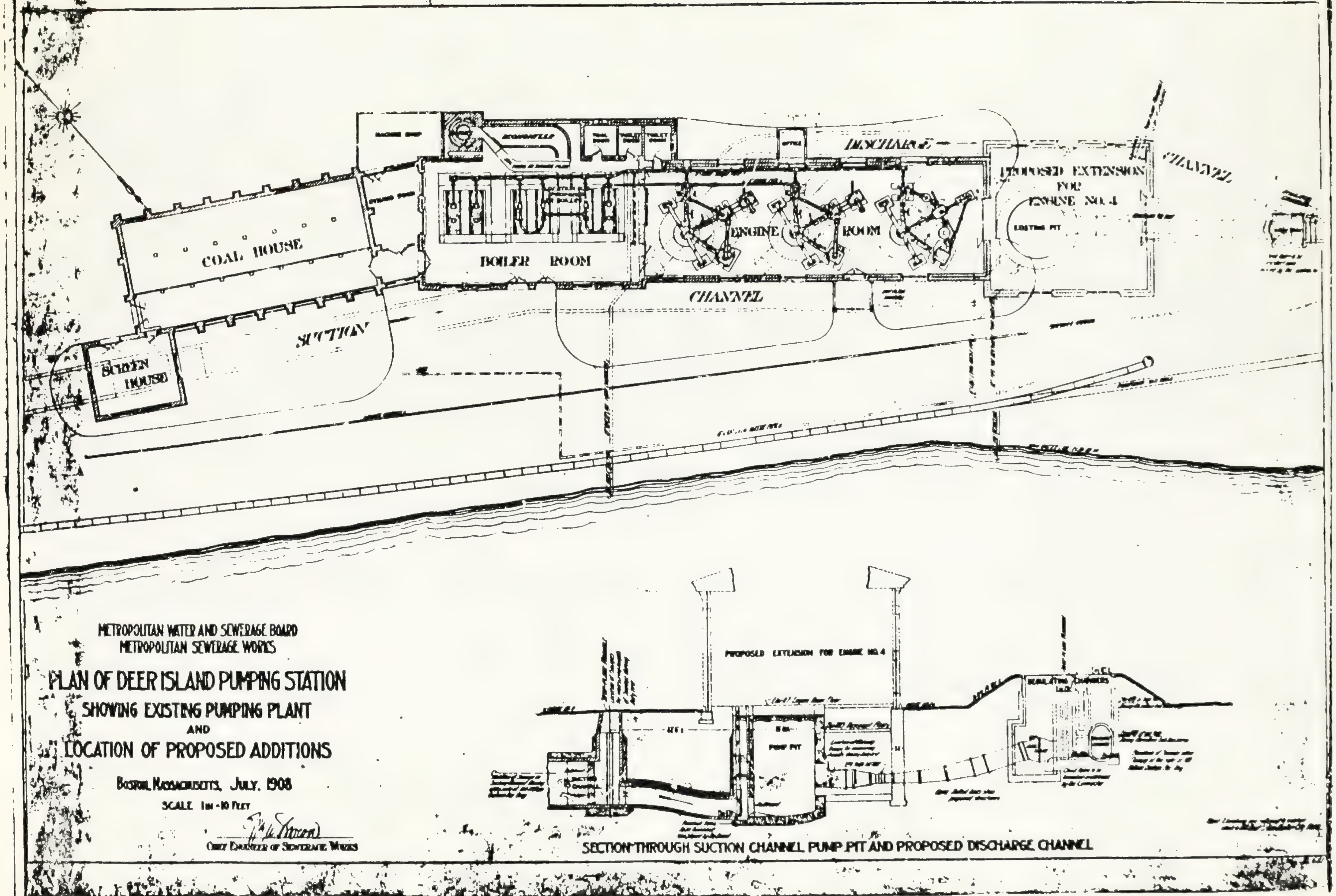

SCREEN CAGE
SCREEN CAGE
Plan of Lower Part
Showing Sections through Counterweight and Screen Guides
DRIVING GEAR WHEELS
NOTE - THE ENGINES FOR THE MAIN CHANNEL TO BE CHANGED TO OPPOSITE END OF FRAME
Plan of Upper Part
Showing Assembly of Framing, Shafting and Gearing
TABLE OF DIMENSIONS FOR SCREEN CAGES
MAIN CHANNEL
BY-PASS CHANNEL
DRIVING GEAR WHEELS
SPROCKET GEAR WHEELS
BRAKE
THROTTLE
REVERSE
CLUTCHES
METROPOLITAN WATER AND SEWERAGE BOARD
METROPOLITAN SEWERAGE WORKS
DETAILS FOR SCREENING MACHINERY
DEER ISLAND PUMPING STATION
DECEMBER 1909
CHIEF ENGINEER OF SEWERAGE WORKS
SCALE 1INCH=1FOOT
Side Elevation of Structure
Elevation looking up stream
Sheet No. 1

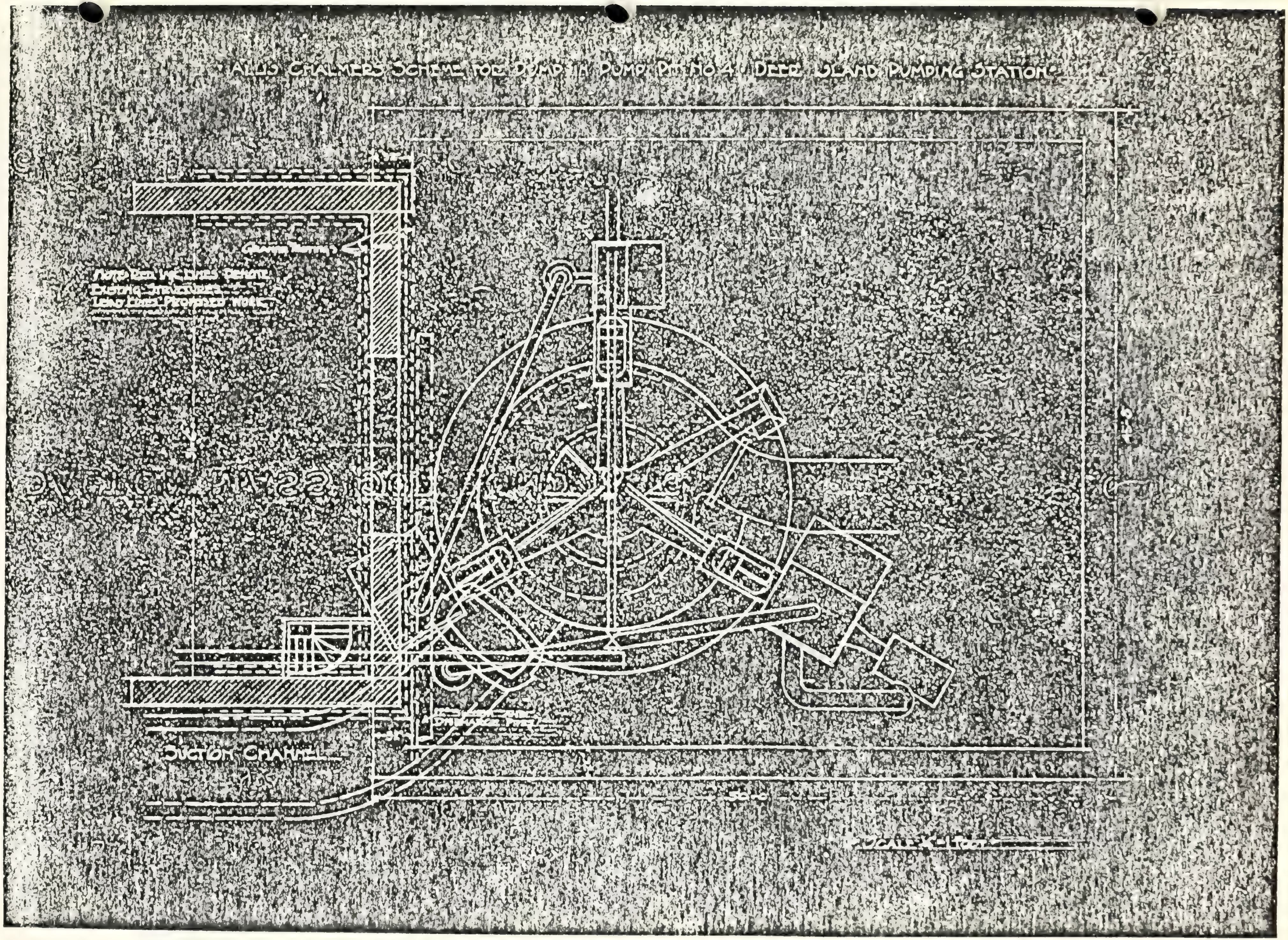


METROPOLITAN WATER AND SEWERAGE BOARD
METROPOLITAN SEWERAGE WORKS
PLAN OF
WHARF AND COAL-RUN
AT
DEER ISLAND PUMPING STATION
PROFILE OF 24" SUCTION PIPE
PLAN OF WHARF AND COAL-RUN
PLAN AT MANHOLE
ELEVATION OF BENTS
SECTION A-B
A
B
C

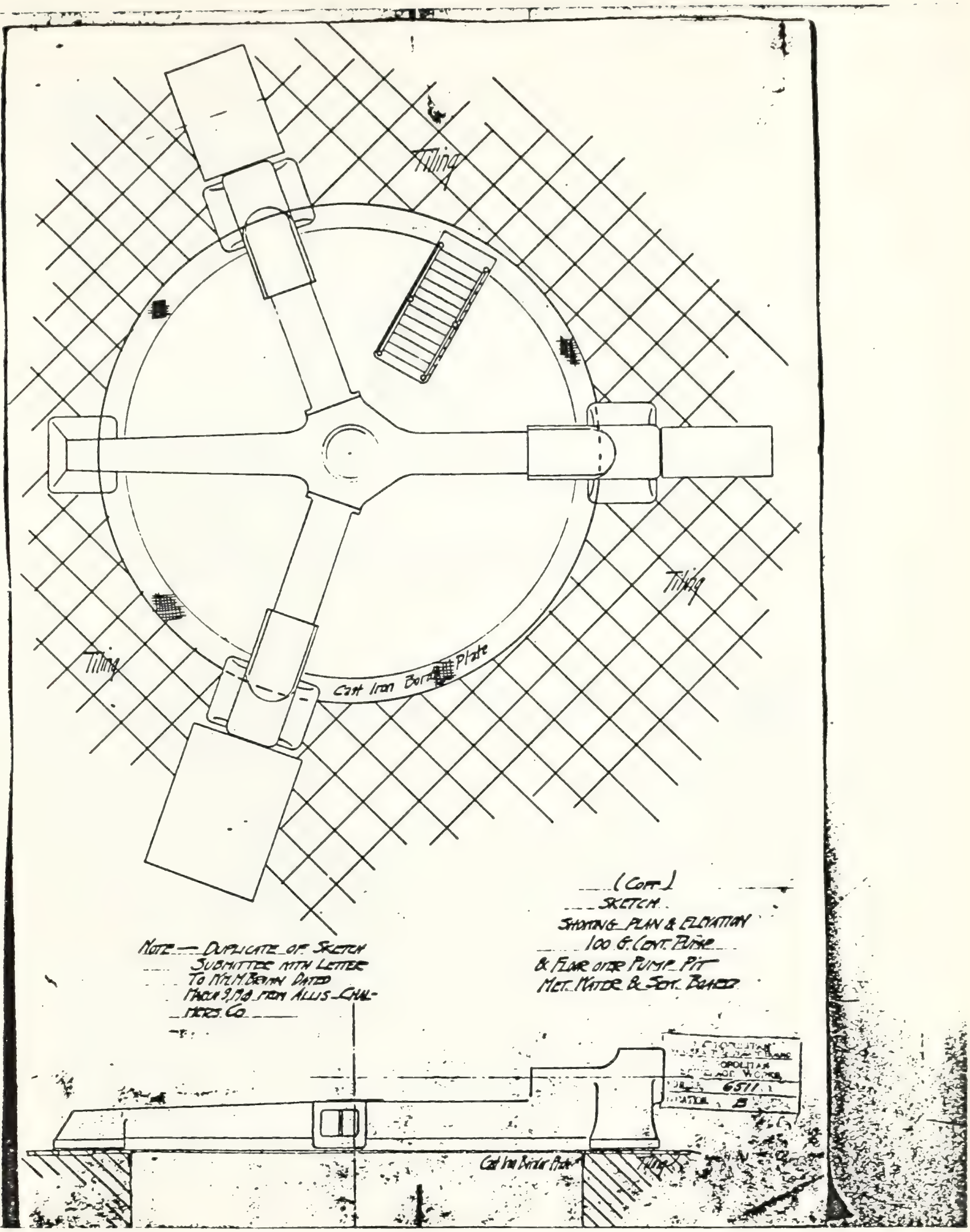


COAL HOUSE EXTENSION AND SCREENING ROOM


COAL HOUSE
SCREEN HOUSE
SUCTION
BOILER ROOM
ENGINE ROOM
CHANNEL
DISCHARGE
CHANNEL
PROPOSED EXTENSION FOR ENGINE NO. 4
EXISTING PIT
PROPOSED EXTENSION FOR ENGINE NO. 4
PUMP PIT
METROPOLITAN WATER AND SEWERAGE BOARD
METROPOLITAN SEWERAGE WORKS
PLAN OF DEER ISLAND PUMPING STATION
SHOWING EXISTING PUMPING PLANT
AND
LOCATION OF PROPOSED ADDITIONS
BOSTON, MASSACHUSETTS, JULY, 1908
SCALE 1 IN = 10 FEET
CHIEF ENGINEER OF SEWERAGE WORKS
SECTION THROUGH SUCTION CHANNEL PUMP PIT AND PROPOSED DISCHARGE CHANNEL



PLAN FOR PUMP AND ENGINE NO. 4



PLAN AND ELEVATION OF ENGINE NO. 4

PHOTOGRAPHS OF THE DEER ISLAND SEWERAGE WORKS

Arranged in order of the sewerage works components described in the text: Screen House - Coal House - Boiler House - Engine Room and Extension

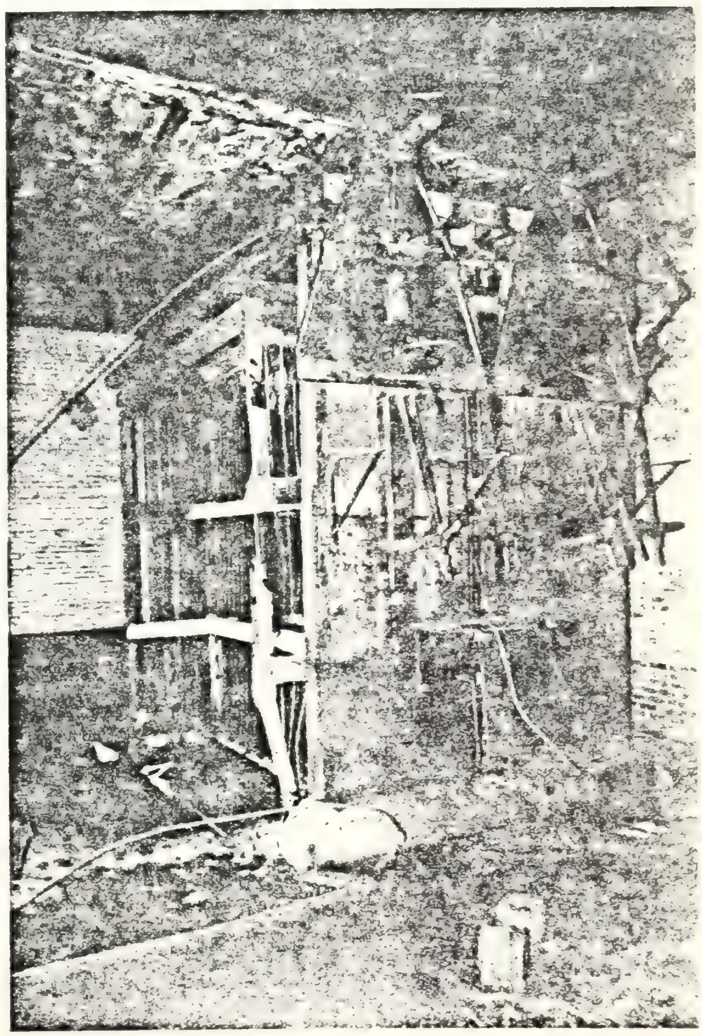
September 14, 1987

Jeffrey C. Howry

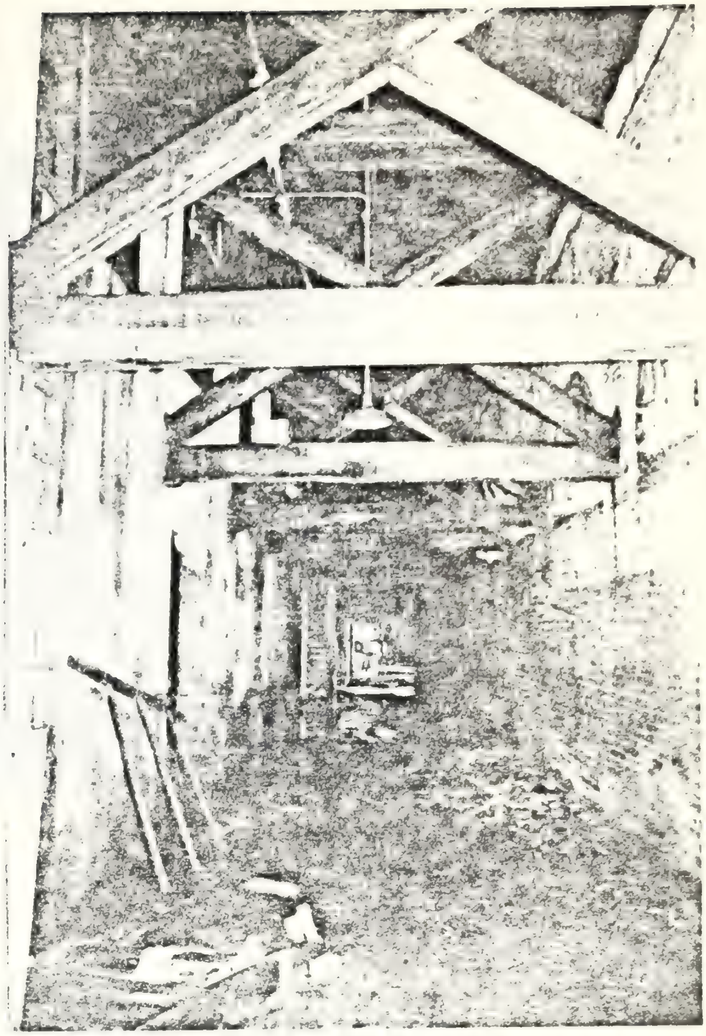
South Elevation of original Engine House (1895)
and Two-story Extension (1909)

South Elevation of Coal House (1895)
and Two-story Screen House (1895)

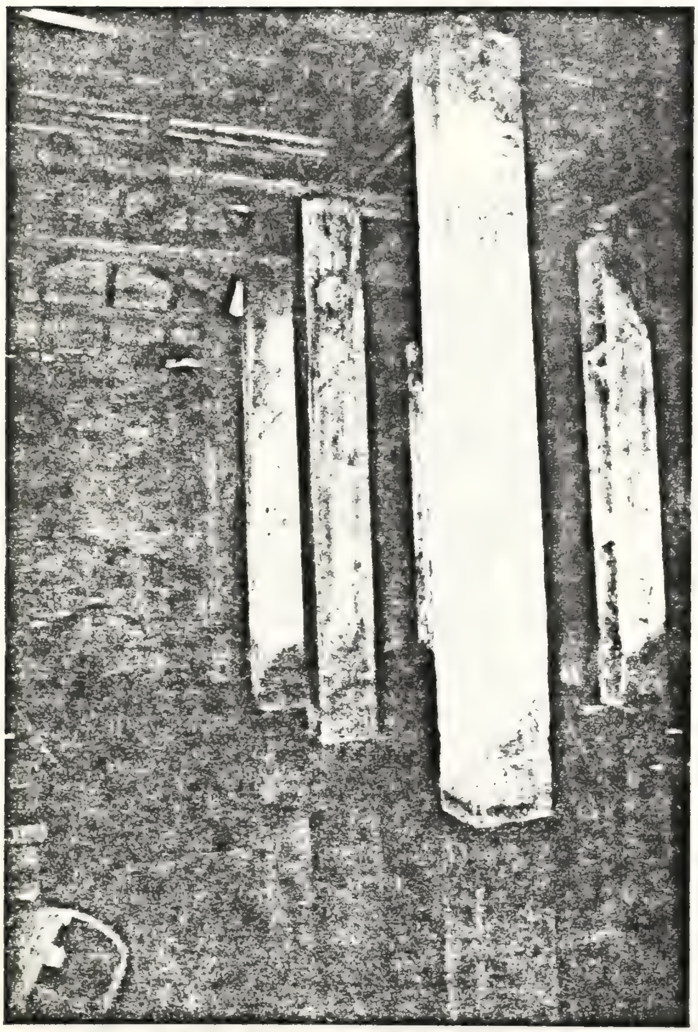
Screening Machinery (1895)



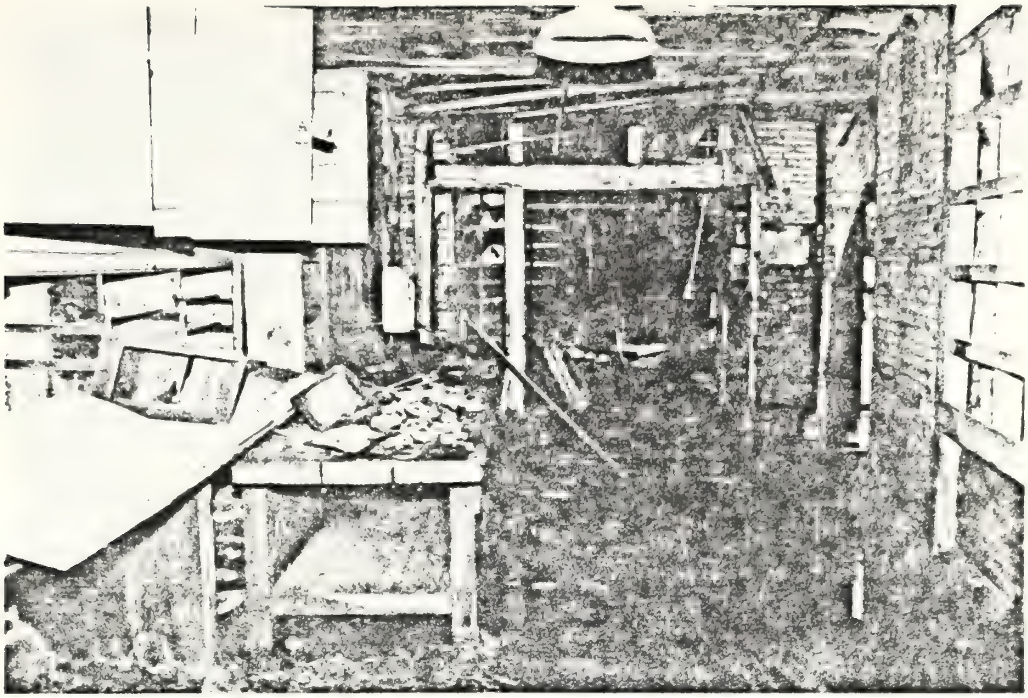
Screening Machinery (1909)



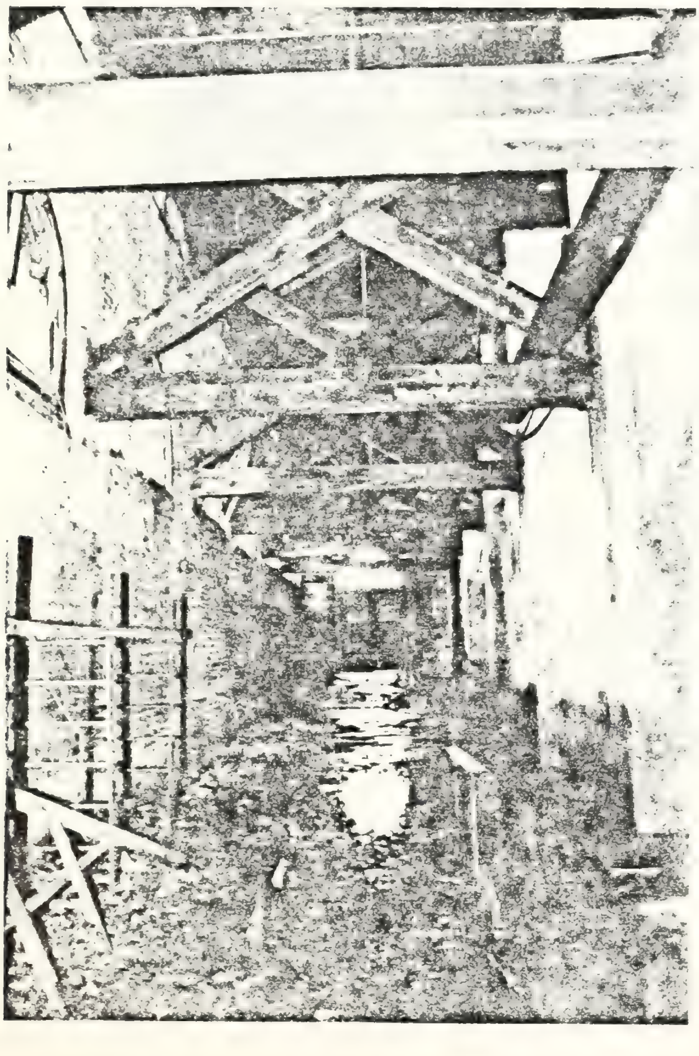
View South along Coal House corridor toward Boiler House



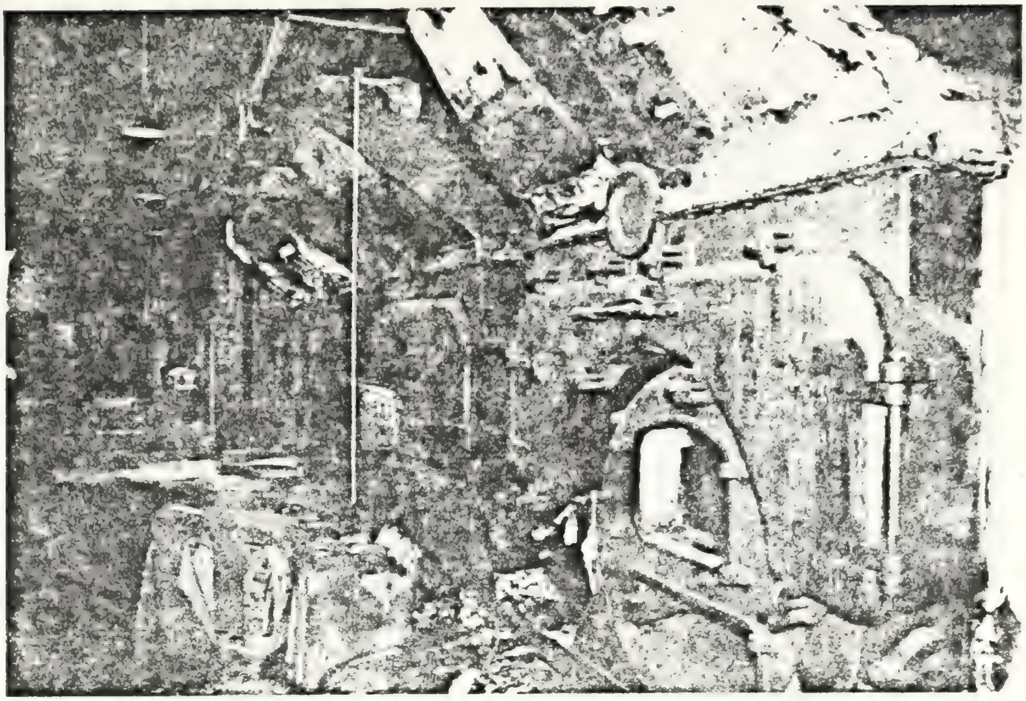
Interior view of Coal House



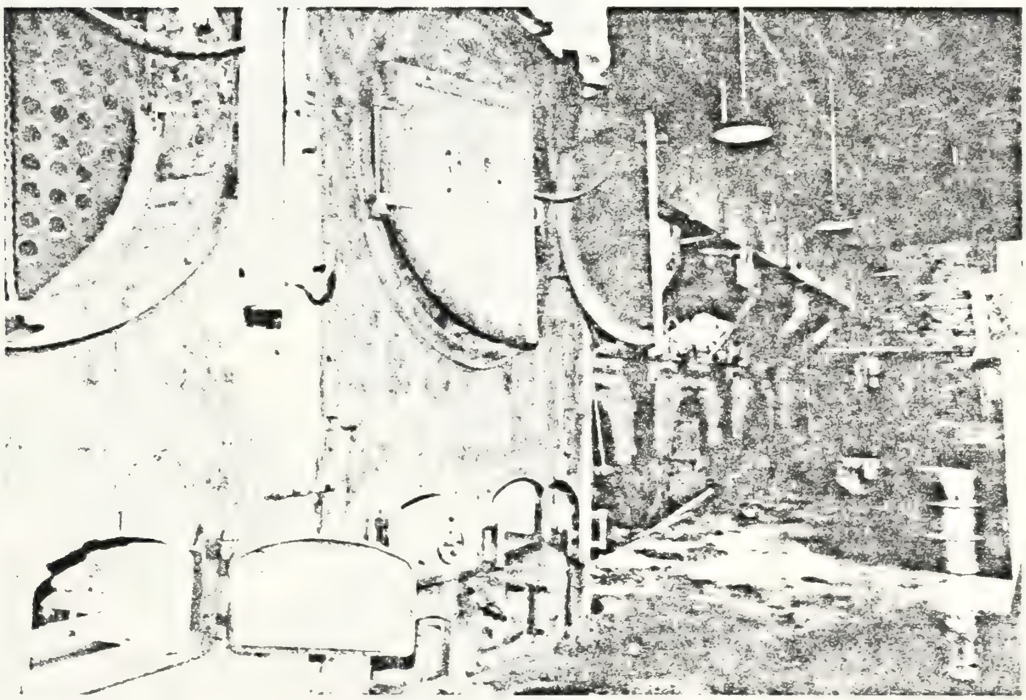
Workshop area between Boiler House and Coal House



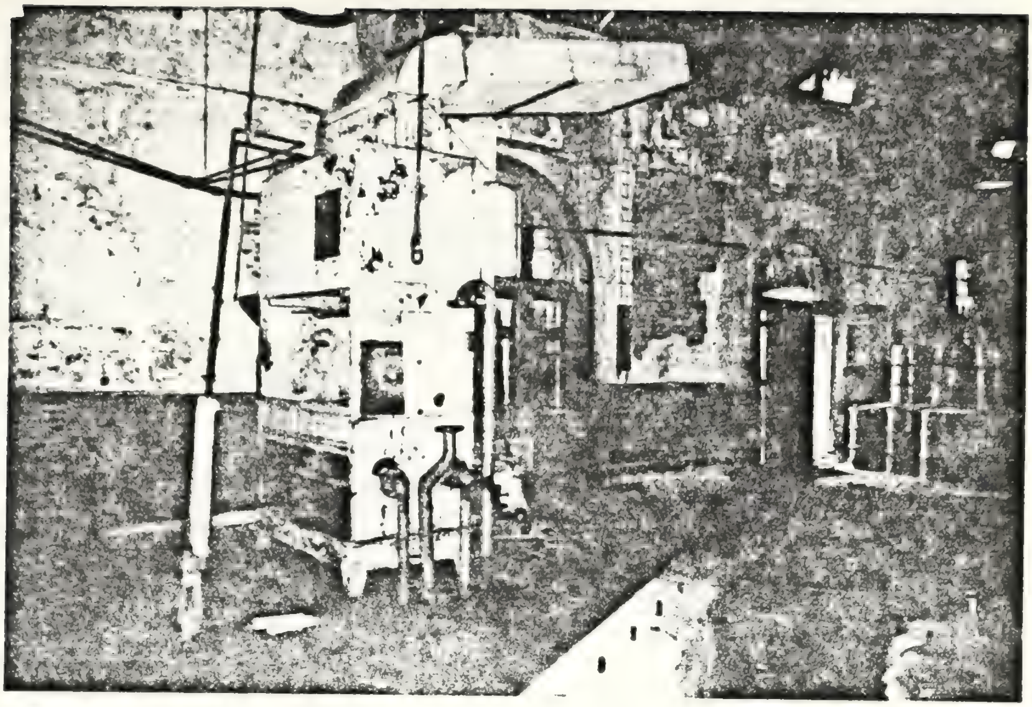
View North Along Coal House corridor toward Screen House



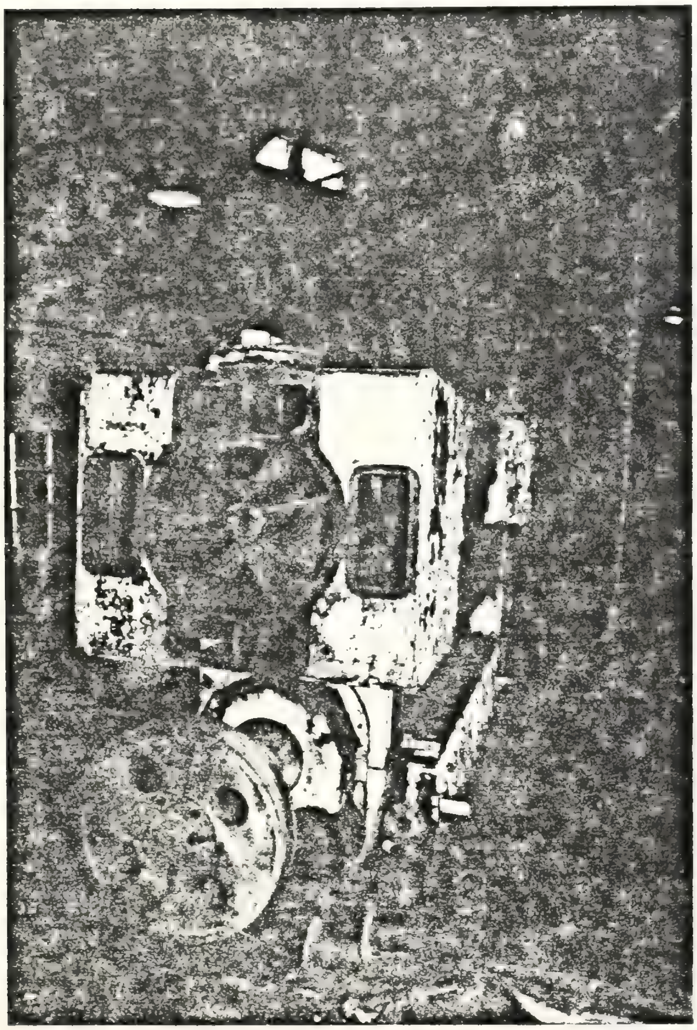
Edward Kendall & Sons boilers installed 1895



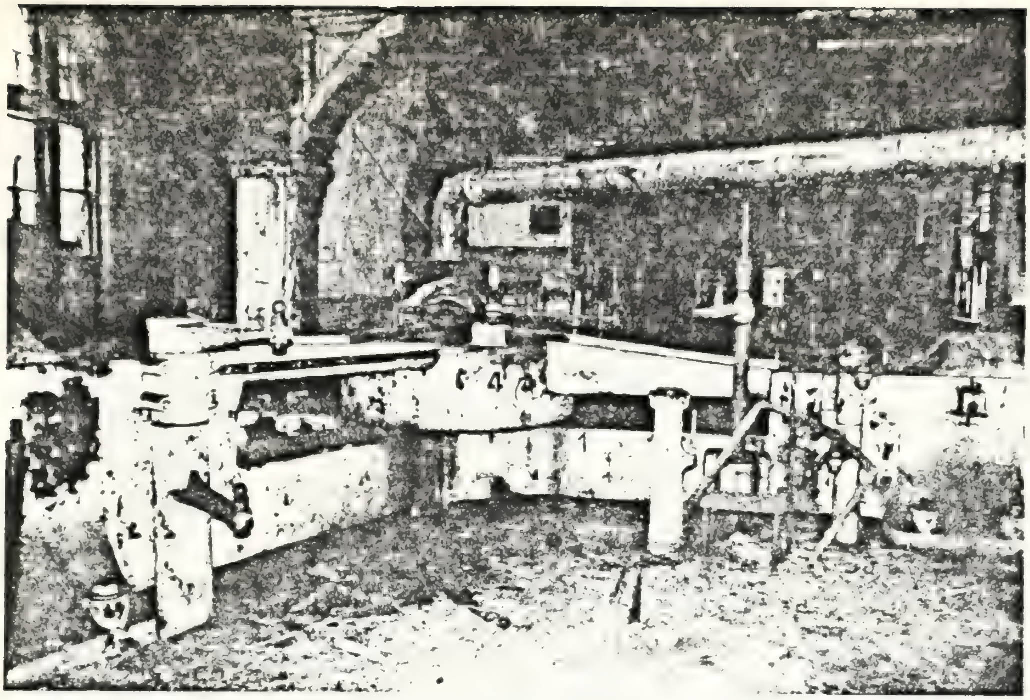
Boilers installed in 1909



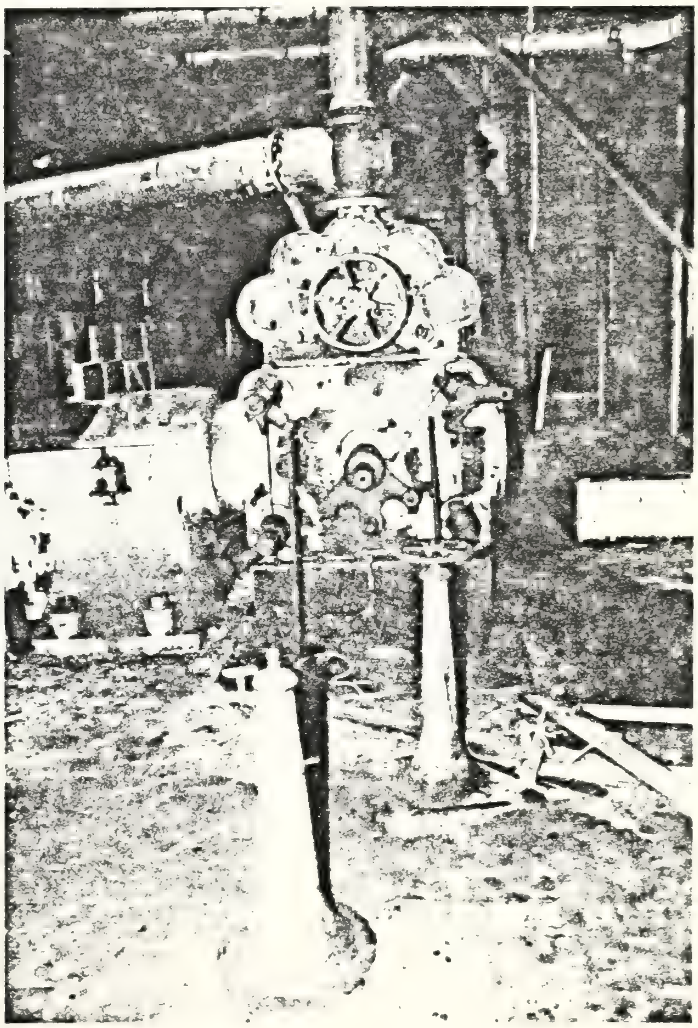
View of Pump Well No. 3 toward Engine House entrance
showing diesel engine footing at right foreground
and diesel engine cooling unit at left



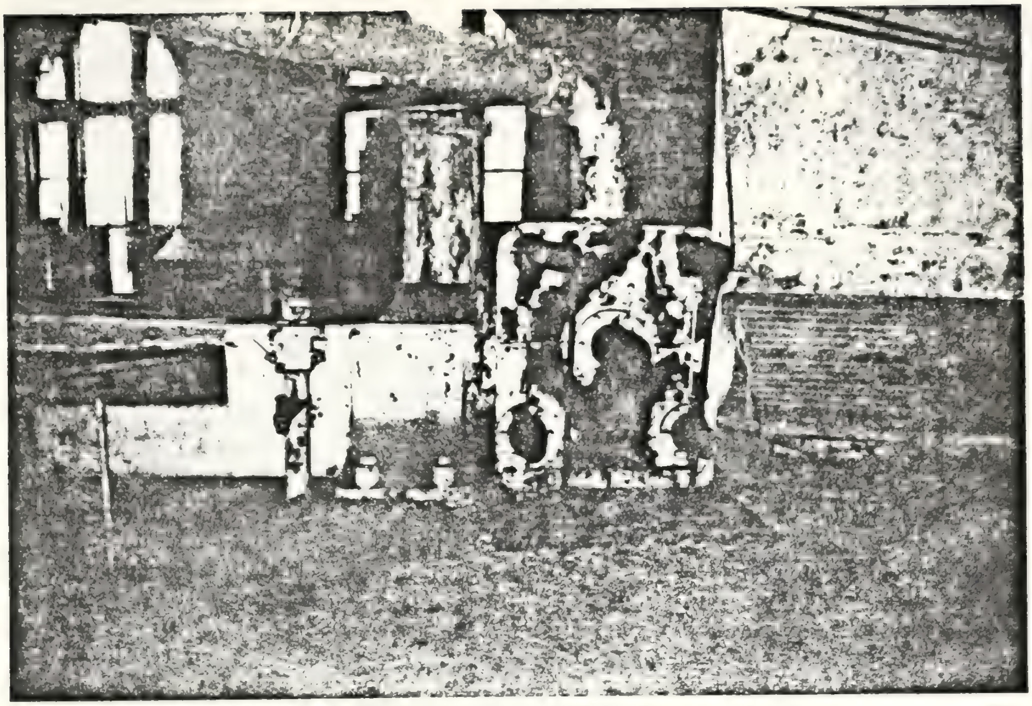
Diesel Engine block at
Pump No. 2



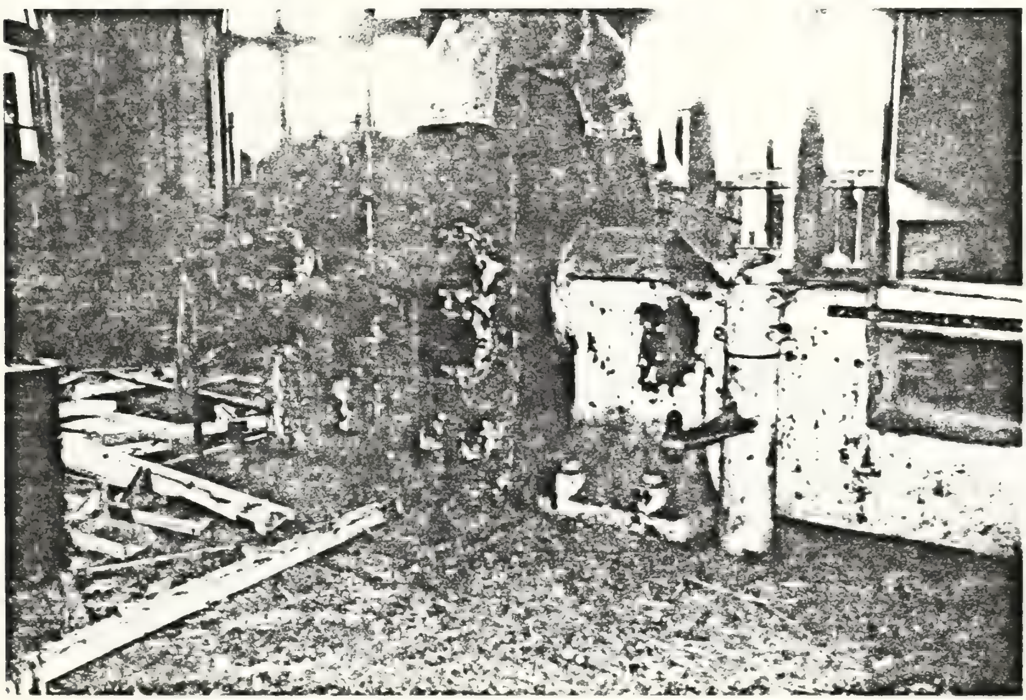
Engine No. 4 - View of intersecting piston shafts at central cam located above vertical shaft connecting to centrifical pump (high presssure piston on right, mid-pressure piston on left, and low pressure piston on left)



Engine No. 4
High Pressure piston
and pump value controls
(foreground)



Engine No. 4 - Mid-pressure piston



Engine No. 4 - Low-pressure piston

Coal Cart

"Farmhouse" south of Pumping Station

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APPENDIX S

SATELLITE PARKING STUDY FOR BUS TRANSPORT FROM REVERE, CHELSEA, AND BOSTON TO DEER ISLAND

The BSC Group

SATELLITE PARKING STUDY
FOR BUS TRANSPORT
FROM REVERE, CHELSEA,
AND BOSTON TO
DEER ISLAND

MARCH 25, 1988

Prepared For:

Massachusetts Water
Resource Authority
Charlestown Navy Yard
100 First Avenue
Boston, MA 02129

Prepared By:

The BSC Group - Boston, Inc.
425 Summer Street
Boston, MA 02210

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

1.0 EXECUTIVE SUMMARY

As part of the court-ordered construction of new wastewater treatment facilities at Deer Island, transport of construction workers will be accomplished by ferrying and busing. The ferrying of half the construction workforce to and from Deer Island is the subject of the Water Transportation Facilities Assessments. The remaining personnel will be bused to Deer Island from a satellite parking site(s). This report identifies candidate sites for satellite parking in East Boston, Revere, and Chelsea.

Evaluation criteria were applied to screen 16 locations in these cities to identify those sites that could meet the peak parking demand for the Deer Island workforce. The potential also exists to use more than one site to meet this demand, however, this report evaluated each of the recommended sites on the basis of adequate parking capacity for the peak year of 1992. Those sites that were not recommended for further consideration are also described herein.

The sites that best meet the criteria are:

- Suffolk Downs
- MDC property on Ocean Avenue (Revere)
- MBTA property at Wonderland (Revere)
- MBTA parking at Beachmont (Revere)
- Towle property (East Boston)
- Parkway Plaza (Chelsea)
- Eastern Minerals (Chelsea)

These sites are accessible to Deer Island via the existing road network and range in round trip travel time from 22 to 45 minutes. Consideration was also given to the potential for joint ventures or shared parking arrangements. The screening of sites is described in detail in Section 5.0.

Peak worker activity is scheduled to occur at Deer Island in the year 1992. Of the total 1,851 workers estimated in that year, 50 percent or 926 workers will be bused over three shifts. Approximately two-thirds of the workers will be on the first shift.

Should there be overlap between the first shift and either the second or third shifts, then the number of parking spaces required is one half of the total workforce on the first shift (1,222) and the second shift (315) or 769 spaces. This represents the maximum number of parking spaces required in the peak year of activity at Deer Island. A worker profile for the remaining years in the schedule is presented in Section 3.0. If there is no overlap between the first shift and either the second or third shifts, then the number of parking spaces required is one-half of the total workforce on the first shift (1,222) at Deer Island which is 611.

For the seven final sites, traffic engineering analysis will be required to determine existing and projected level of service at intersections proximate to the recommended sites for satellite parking that could be impacted by additional MWRA-related traffic (workers and buses). The report assumes that all commuting to and from the satellite parking sites occurs during off-peak hours. The use of van pooling would reduce the vehicular demand for parking at satellite parking sites. The report also includes a bus operating plan, both in terms of scheduling and routing from the seven recommended sites. Consistent with previous reports on treatment plant siting, a fleet of 16 buses would be required to transport workers on the first shift in the peak year of activity (1992). Four buses would be needed to transport workers on either the second or third shifts. Site development considerations are also discussed for the sites.

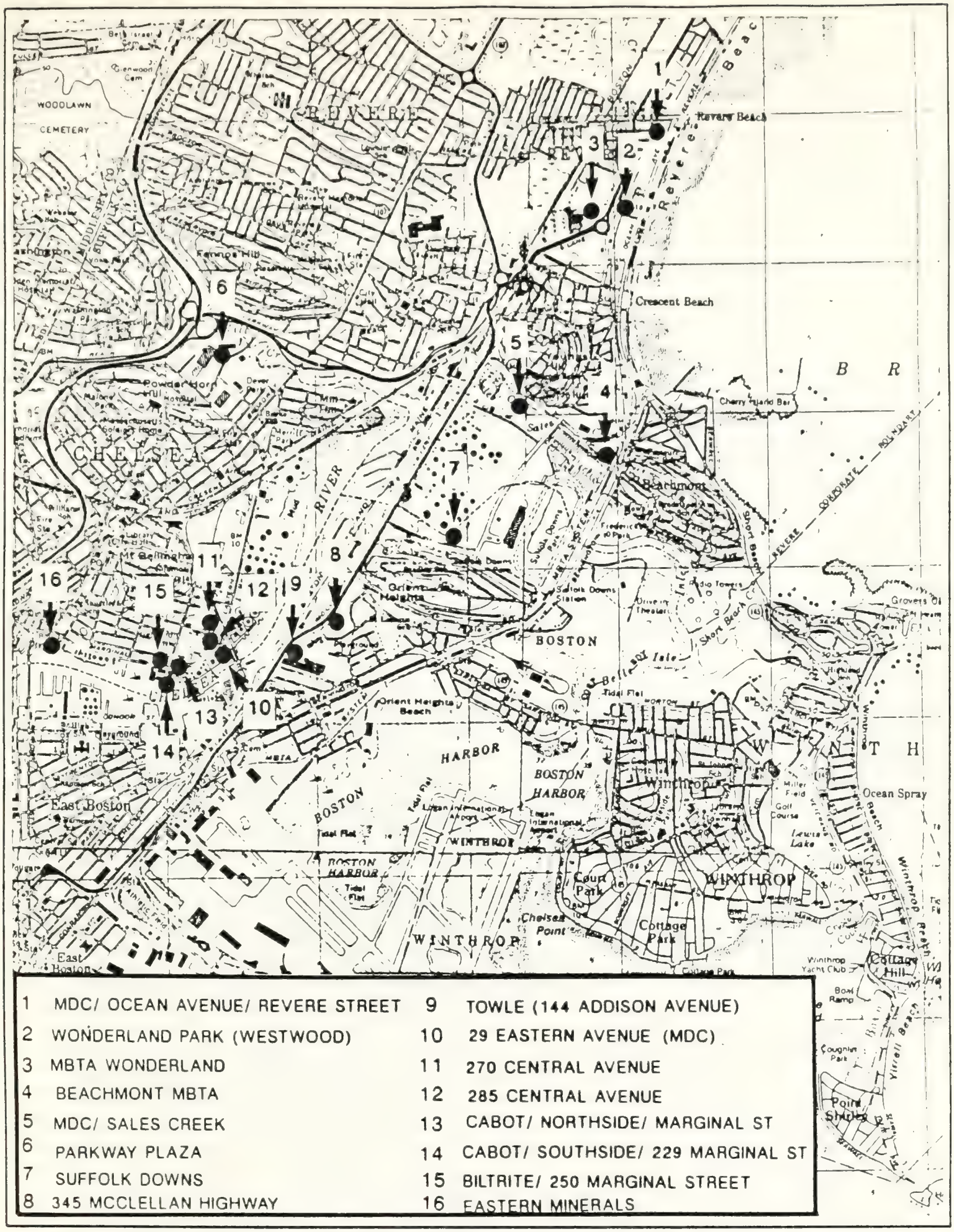
2.0 INTRODUCTION

In order to facilitate the movement of construction personnel to Deer Island during construction of new wastewater treatment facilities between 1990 and 1999, the Massachusetts Water Resources Authority (MWRA) proposes to transport these workers via water and bus. The profile of the numbers of workers during that period is shown on Table 1. As can be seen from this table, the number of workers rises sharply from 188 in 1990 to 1,173 in 1991 to a peak of 1,851 in 1992 and decreases gradually through 1997 and then down to 930 in 1999. The worker transport system being proposed will address the peak worker demand of 1,851 in 1992. Of this total, a minimum of 50 percent of the workers per day will be transported by personnel ferry when on-island and on-shore piers are operational (1990) and the remaining workers will be bused. The water transport of personnel was the subject of the Water Transportation Facilities Assessments prepared by the MWRA.

This report deals with the selection of sites and an implementation plan for bus transport of workers from communities north of Boston. This report builds upon the work done in Volume III, Appendix K, Traffic Impact Analysis, January 7, 1988 for the Secondary Treatment Facilities Plan. The sites evaluated and criteria applied in that report were considered in the completion of this Satellite Parking Study.

Site Identification

A total of 16 locations (3 in Boston, 6 in Revere, and 7 in Chelsea) were identified based on meetings and telephone conversations with city officials, representatives of the Massachusetts Bay Transportation Authority (MBTA) and Metropolitan District Commission (MDC), private land owners, and realtors (see Figure 1). Information on sites was gathered from assessor's maps, zoning maps, aerial



LOCATION MAP

The BSC Group

PROPOSED SATELLITE PARKING CANDIDATE SITES

Fig. 1

NOT TO SCALE

N

SOURCE: UNITED STATES GEOLOGICAL QUADRANGLES; BOSTON NORTH, BOSTON SOUTH, LYNN, HULL, MA.

photography, open space plans, and field inspection. Ownership information was obtained from direct contact with site owners, lessees, or municipal officials. A major factor in this site selection process was the potential for joint ventures or shared use of the sites with other public and private entities to serve as parking areas for MWRA bus transportation to Deer Island.

Criteria were developed to screen the sites for general suitability. The criteria included worker access, proximity to Deer Island, parking capacity, land use compatibility, availability, land area, and known history of hazardous materials.

As information was obtained, the evaluation of sites became more specific. Evaluation criteria were refined and site characteristics were compared. A matrix (Table 2) was used to compare the sites. The vertical column of the matrix lists site characteristics and names of sites make up the horizontal row. Specific features of each site are located in the cells at the intersection of columns and rows.

For purposes of this study, it was assumed that parking at the satellite locations could either be in surface lots or, where warranted by site conditions, in structured parking garages. Joint venture arrangements on structured parking are discussed later in this report.

Failure to comply with critical criteria, (i.e. available for purchase or lease, consistent with plans of owner) resulted in sites being considered unsuitable. However, failure to comply with other criteria (i.e. compatibility with plans of others) led to some sites being considered less suitable. A description of the criteria applied is in Section 4.0. A description of the evaluation of sites is in Section 5.0. The bus operating plan, routes, and site development considerations are included in Section 6.0.

3.0 WORKER PROFILE

The number of workers required for construction and operations activities at Deer Island fluctuates with the various phases of the proposed wastewater treatment project. The numbers used in this study were generated by facilities planners for the Secondary Treatment Plant (Vol. III, Appendix K, March 1988).

In order to identify the number of parking spaces and bus operating plan required for the satellite parking system, a worst case scenario was established. This scenario assumes an overlap of first and second shifts or first and third shifts at Deer Island. Of the total number of workers from these shifts, 50 percent of the workers will be ferried by water to Deer Island when on-island and on-shore piers are operational in 1990. The remaining number will be bused to Deer Island.

Table 1 shows a profile of the number of workers for the three shifts at Deer Island. The number of parking spaces listed assumes one space for each construction worker at the satellite parking facilities. However, the use of vanpools or carpools, through organizations such as Caravan For Commuters, may also be feasible to satellite parking sites and reduce the number of spaces needed. The shift times assumed are:

TABLE 1

Construction and Operations Worker Profile
(Peak #'s)

DEER ISLAND

	1st Shift	2nd Shift	3rd Shift	Total	Workers Ferried	Workers Bused
1990*	124	32	32	188	94	94
1991*	174	200	199	1173	586	586
1992	1222	315	314	1851	926	925
1993	1160	299	299	1758	879	879
1994	1127	291	290	1708	854	854
1995	1020	263	263	1546	773	773
1996	994	256	256	1506	753	753
1997	1042	268	268	1578	789	789
1998	669	172	172	1013	507	506
1999	614	158	158	930	465	465

NOTES:

* Does not include House of Corrections Workers

1) Assumes 50% of Deer Island workers ferried and 50% bused when on-island and on-shore piers operational.

2) Peak year 1992 - 50% of 1st shift (1222) plus 2nd shift (315) = # of spaces required (769) for parking.

Source: STFP 3/21/88

Deer Island

Shift	Leaves Satellite Parking Site(s)	Arrives Deer Island	Leaves Deer Island	Arrives Satellite Parking Site(s)
1	6:00 a.m.	6:30 a.m.	2:30 p.m.	3:00 p.m.
2	3:30 p.m.	4:00 p.m.	12:00 a.m.	12:30 a.m.
3	10:30 p.m.	11:00 p.m.	5:00 a.m.	5:30 a.m.

Based on the worker profile depicted on Table 1, the following characteristics of the workforce and the mode by which they will be transported to and from Deer and Nut Island were used in this report.

Deer Island

- o In years 1988 and 1989 prior to on-island and on-shore piers being operational, workers will be transported by private automobile. The MWRA may attempt to implement a pilot busing program in 1988 and 1989. The locations from which workers may be bused to Deer Island in these two years may differ from those short-listed sites recommended herein that will be in service from 1990 to 1999.

- o From 1990 to 1999 when on-island and on-shore piers are operational, it is assumed that 50 percent of the construction workforce at Deer Island will be bused and 50 percent will be ferried.

- o The worker profile for Deer Island does not include House of Correction workers or Fast Track workers in 1988 or 1989. It also does not include House of Correction workers in 1990 and 1991.

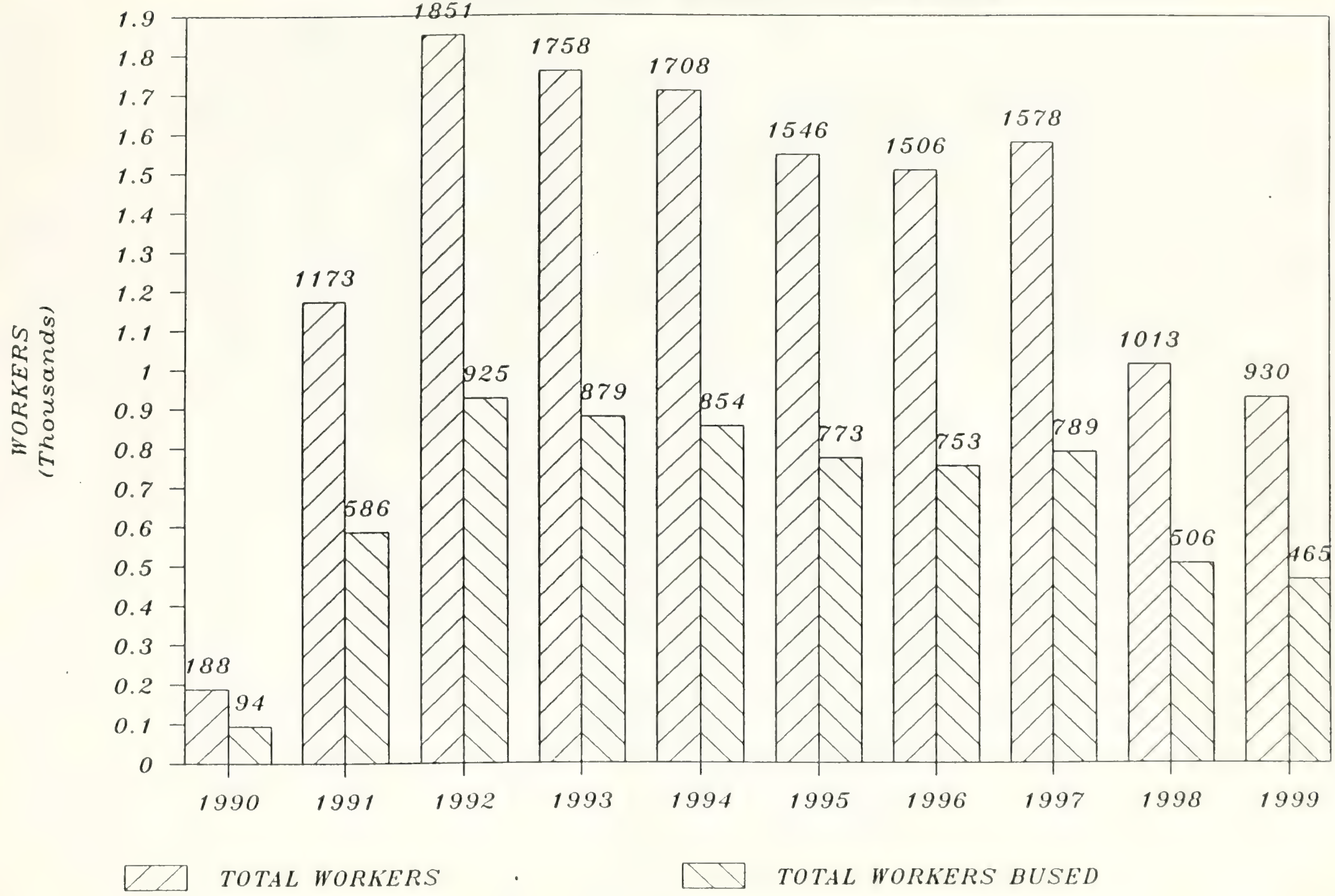
- As noted on Table 1, the peak year for construction plus operations workers at Deer Island is 1992 when a total of 1,851 workers will be on-site. Of that total, 925 or 50 percent will be bused to Deer Island over three shifts. Should there be overlap between the first shift and either the second or third shifts, then the number of parking spaces required would be one-half of the total workforce on the first shift and the second shift or 769 spaces. The remaining workers will be ferried. Of the 1992 yearly total, 1,222 workers will be on the first shift and if there is no overlap 611 (or 50 percent) of those workers will be bused. The total of 769 workers sets the assumed capacity of satellite parking sites.

- All seven short-listed sites have sufficient capacity to meet the parking demand in the peak year (1992) of 611 spaces which is the required number of spaces in the peak year with no overlap of shifts. The Beachmont MBTA station has a capacity of 394 spaces in a surface layout and therefore would require structured parking at Beachmont to meet the peak demand of 769 spaces in 1992. Similarly, the MDC Ocean Avenue site has a capacity of about 500 spaces at grade and would require structured parking to meet the peak worker demand. The Eastern Minerals site in Chelsea would have a shortfall of capacity during the years 1992, 1993 and 1994 if there is overlap between first and second shifts. The shortfall for those three years would be 94, 55 and 34 spaces, respectively. This shortfall could be addressed in concert with other satellite parking sites or water transport ferry sites.

- It is important to note the range of the worker profile shown in Table 1. In the early years of the project (1988 to 1990) the total number of workers at Deer Island ranges from 167 to 285. However, from 1991 to 1999, the number of workers varies from 1,173 to a peak of 1,851 in 1992 and decreases to 930 in 1999. A graphic representation of the Deer Island peak worker profile is shown on Figure 2.

DEER ISLAND

FIGURE 2: TOTAL WORKERS/TOTAL BUSED



4.0 DESCRIPTION OF EVALUATION CRITERIA

Site characteristics examined for the candidate satellite parking sites are described in greater detail below.

Land Access

The following two standards were applied to each site:

- Distance to highway - Whereas the commute to the satellite parking site is one part of the work trip, the distance to a major travel artery should be minimized. Satellite parking locations recommended are located two miles or less from regional highway connections. The distance is listed in statute miles on Table 2.

- Proximity to Deer Island - The travel times to Deer Island were based on actual trips during off-peak hours over the proposed access routes. Recommended sites were no more than 30 minutes for a one way trip to Deer Island. The time is listed in minutes.

Land Use Compatibility

The compatibility of the proposed satellite parking facilities with other adjacent land uses was assessed for each site. The criterion assumed adequate set back away from residences and other sensitive uses (schools, hospitals, fire and police stations, libraries and churches) to minimize impact from workers arriving/departing in the early morning or late night hours. Land use was determined by windshield survey of all sites and in some cases aerial photography and other published sources. Evaluation included compatibility with:

- Existing uses on the site (can parking and present uses coexist?)

- Abutting uses (is parking compatible with uses of surrounding property?)
- Plans of owner (is it the intent of owner for some other use on site?)
- Plans of others (are there community, public or private plans for incompatible uses on the site?)

Availability

Information on availability was gathered through discussions with site owners, occupants, municipal officials, and realtors. Sites which could neither be leased nor purchased were considered unsuitable. Sites occupied by one firm in an established business and sites where occupants had long term leasing options were considered less suitable sites. The availability criteria were:

- availability for lease
- availability for purchase
- existing leases
- present occupants
- length of occupancy for present occupant
- expiration of present lease
- earliest available date
- potential for joint venture or cost sharing

Parking Capacity/Land Area

Land area and availability of convenient parking are critical aspects for an efficient bus shuttle service to Deer Island. Larger sites would be preferable to a number of smaller sites, which require greater coordination and offer less parking spaces unless structured parking is a feasible alternative. Construction and operations personnel would not park on local streets. An allotment of 300 square feet per parking space was used to allocate the number of

parking spaces on available open space unless more specific figures were available or a structured arrangement was recommended for the site. The land area listed in acres, was determined from owner's information, published sources, or property and assessor's maps.

Presence of Hazardous Material - 21E Status

The history of hazardous materials on a site was determined by a search of sites on file at DEQE's northeast regional office in Woburn and on the basis of existing and previous land use. Sites used for storage of chemical products were assumed to have the potential to contain hazardous materials. Sites with a history of the presence of hazardous materials and unresolved contaminant problems were considered less suitable than those sites without such history.

5.0 SITE SCREENING/EVALUATION

The process used to select satellite parking sites required that the location be no more than 30 minutes off-peak travel time to or from Deer Island (one way trip) and that the site be within two miles of the regional highway system. This process narrowed choices to the cities of Boston, Revere, and Chelsea. Factors considered were:

- land access
- land use compatibility
- availability
- land area for parking lot
- history of hazardous materials

The access routes from the nearest highway connection to the various sites were evaluated as well as routes from the sites to and from the Deer Island (see Bus Operating Plan). Route characteristics such as roadway width, geometrics,

signalization, and accessibility to public transit were also used in screening. Construction personnel should not have to walk more than 2,000 feet from transit to the bus to Deer Island.

The land area required for parking differs according to the geographic location and whether structured parking is called for. Parking area requirements were based on 300 square feet per car. The number of parking spaces needed at each location was compared to the land area available.

Satellite parking sites were identified to minimize the need to travel through residential areas that might be impacted by vehicular traffic. Of additional concern was the compatibility of the proposed parking use with the plans of the owner. With the urgency for identifying an implementable bus system, discussions which resulted in expressions of interest from site owners became a prerequisite to sites being recommended for further scrutiny.

A file search was conducted at DEQE's northeast regional office in Woburn on March 4, 1988 to determine the documented record of hazardous material exposure at the sites under consideration.

Final Sites

Of the 16 sites evaluated, 7 sites are recommended for busing construction personnel to Deer Island (see Table 2 Candidate Site Characteristics). These sites were recommended because they met the most essential needs established for a satellite parking facility, although they did not necessarily meet all criteria. The sites were considered as part of a system meeting the fluctuating needs of the Deer Island project between 1990 and 1999. The final sites are:

TABLE 2 CANDIDATE SITE CHARACTERISTICS

CHELSEA SITES

	PARKWAY PLAZA	270 CENTRAL AVENUE	285 CENTRAL AVENUE	29 EASTERN AVENUE (MDC)	250 MARGINAL STREET	CABOT/ NORTH SIDE/ MARGINAL ST.	CABOT/ SOUTH SIDE/ 229 MARGINAL STREET	EASTERN MINERALS
Owner	Patrick J. Glynn	M-C Realty & Highway Assoc.	M-C Realty II & Highway Assoc.	Commonwealth of Massachusetts MDC	Biltrite Corp.	Samuel Cabot Inc.	Samuel Cabot Inc.	SMP Trust - David & Daniel Mahoney
Land Access								
On Numbered Route	Yes	No	No	No	No	No	No	No
Distance to Highway	0	1500'	1500'	1500'	2500'	2500'	2500'	1200'
Proximity								
Distance to D.I. (miles)	6.3	7.1	7.1	7.1	7.4	7.4	7.4	7.9
Travel Time to D.I. (min.)	16.5	20.5	20.5	20.5	21.5	21.5	21.5	22.5
Parking								
Potential Capacity (300 sq. ft./car)	800	494	110	70	247	192	740	549
Existing Parking	Yes	No	No	No	No	No	No	No
Compatibility								
W/Present Uses	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
W/Abutting Uses	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
W/Plans of Owner	Yes	?	?	?	?	?	Yes	?
Availability								
For Lease	Yes	Yes	?	?	Yes	Yes	Yes	?
For Purchase	No	?	?	?	No	No	?	?
Existing Leases	Yes	NA	NA	?	?	?	Yes	?
Duration of Present Lease	?	NA	NA	?	?	>	*	?
Present Occupant(s)	Yes	NA	NA	?	?	?	Aqua kleen	?
Land Area								
Total Acreage	35.0	3.4	0.75	0.60	1.7	1.32	6.4	4.7
Open Space Available	5.5	3.4	0.75	0.48	1.7	1.32	5.1	4.7
Hazardous Potential								
DEQE Records	No	No	No	No	No	No	Yes	No
Further Study								
Recommended	Yes	No	No	No	No	No	No	Yes

TABLE 2 (CONT.)

REVERE SITES

	MDC LAND/@ OCEAN AVENUE/ REVERE STREET	WONDERLAND PARK (WESTWOOD)	BEACHMONT MBTA	MDC/ SALES CREEK	WONDERLAND/ MBTA
Owner	Commonwealth of Massachusetts MDC	Wonderland Greyhound Park, Inc.	Commonwealth of Massachusetts MBTA	Commonwealth of Massachusetts MDC	Commonwealth of Massachusetts MBTA
Land Access					
On Numbered Route	No	Yes	Yes	Yes	Yes
Distance to Highway	800'	0	500'	0	0
Proximity					
Distance to D.I. (miles)	5.1	6.0	4.4	5.2	5.1
Travel Time to D.I. (min.)	13.5	15.0	11.0	13.0	12.5
Parking					
Potential Capacity (300 sq. ft./car)	500-800 (structured)	800	800 (structured)	465	800 (structured)
Existing Parking	Yes	Yes	Yes	No	Yes
Compatibility					
W/Present Uses	Yes	Yes	Yes	Yes	Yes
W/Abutting Uses	Yes	Yes	Yes	Yes	Yes
W/Plans of Owner	Yes	No	Yes	Yes	Yes
Availability					
For Lease	?	No	Yes	Yes	?
For Purchase	No	No	No	No	No
Existing Leases	None	Yes	No	No	?
Duration of Present Lease	NA	?	NA	NA	NA
Present Occupant(s)	Summer Weekend Parking	MBTA Parking	MBTA Parking	NA	NA
Land Area					
Total Acreage	4.5	39.0	3.5	3.2	3.6
Open Space Available	4.5	5.5	3.5	3.2	3.6
Hazardous Potential DEQE Records	No	No	No	No	
Further Study Recommended	Yes	No	Yes	No	Yes

TABLE 2 (CONT.)

BOSTON SITES

	SUFFOLK DOWNS	345 MCLELLAN HIGHWAY	TOWLE/144 ADDISON AVENUE
Owner	Belle Isle Associates	Edward McCormack Trust	Charles Hill, Leonard Florence, Edward McCormack Trust
Land Access			
On Numbered Route	Yes	Yes	Yes
Distance to Highway	0	0	0
Proximity			
Distance to D.I. (miles)	5.3	7.4	6.1
Travel Time to D.I. (min.)	12.5	16.0	15.5
Parking			
Potential Capacity (300 sq. ft./car)	1234	871	800
Existing Parking	Yes	No	Yes
Compatibility			
W/Present Uses	Yes	No	Yes
W/Abutting Uses	Yes	Yes	Yes
W/Plans of Owner	Yes	?	Yes
Availability			
For Lease	Yes	Yes	Yes
For Purchase	No	No	No
Existing Leases	No	?	No
Duration of Present Lease	NA	?	NA
Present Occupant(s)		?	NA
Land Area			
Total Acreage	100.0	6.0	13.65
Open Space Available	8.5	6.0	5.5
Hazardous Potential			
DEQE Records	No	Yes	No
Further Study Recommended	Yes	No	Yes

- Suffolk Downs
- MDC property @ Ocean Avenue/Revere Street in the City of Revere
- Wonderland MBTA parking in the City of Revere
- Beachmont MBTA parking in the City of Revere
- Towle property in the City of Boston
- Parkway Plaza off Revere Beach Parkway in the City of Chelsea
- Eastern Minerals on Marginal Street in the City of Chelsea

Each of the seven sites is described below. A general plan of the site including parking layout is also provided for each of these short-listed sites. Parking layouts are provided in Figures 3 to 9 for each site.

Suffolk Downs

Suffolk Downs Park occupies over 100 acres in the cities of Boston and Revere. The park offers horse racing from 1:00 P.M. to 5:00 PM daily except Tuesday and Thursday, with a capacity for 20,000 spectators. Parking is provided on site, however, on non-racing days, the parking facilities are virtually unused. The majority of Suffolk Downs Park is located in Boston; however, the property line divides the site such that portions of the racetrack and stable area are located in Revere. Three private access roads enter Suffolk Downs. Two roads exit to the McClellan Highway (Route 1A) in Boston, whereas the third road exits to Route 145 in Revere.

The proposed location for satellite parking at Suffolk Downs would be approximately 8.5 acres off of the McClellan Highway and the racetrack access road. Zoned as a general business district, this portion of the park is paved and striped, and currently surplus to the operating needs of Suffolk Downs. The closest abutting uses are oil tanks in Revere to the north and residences on Waldemar Avenue in

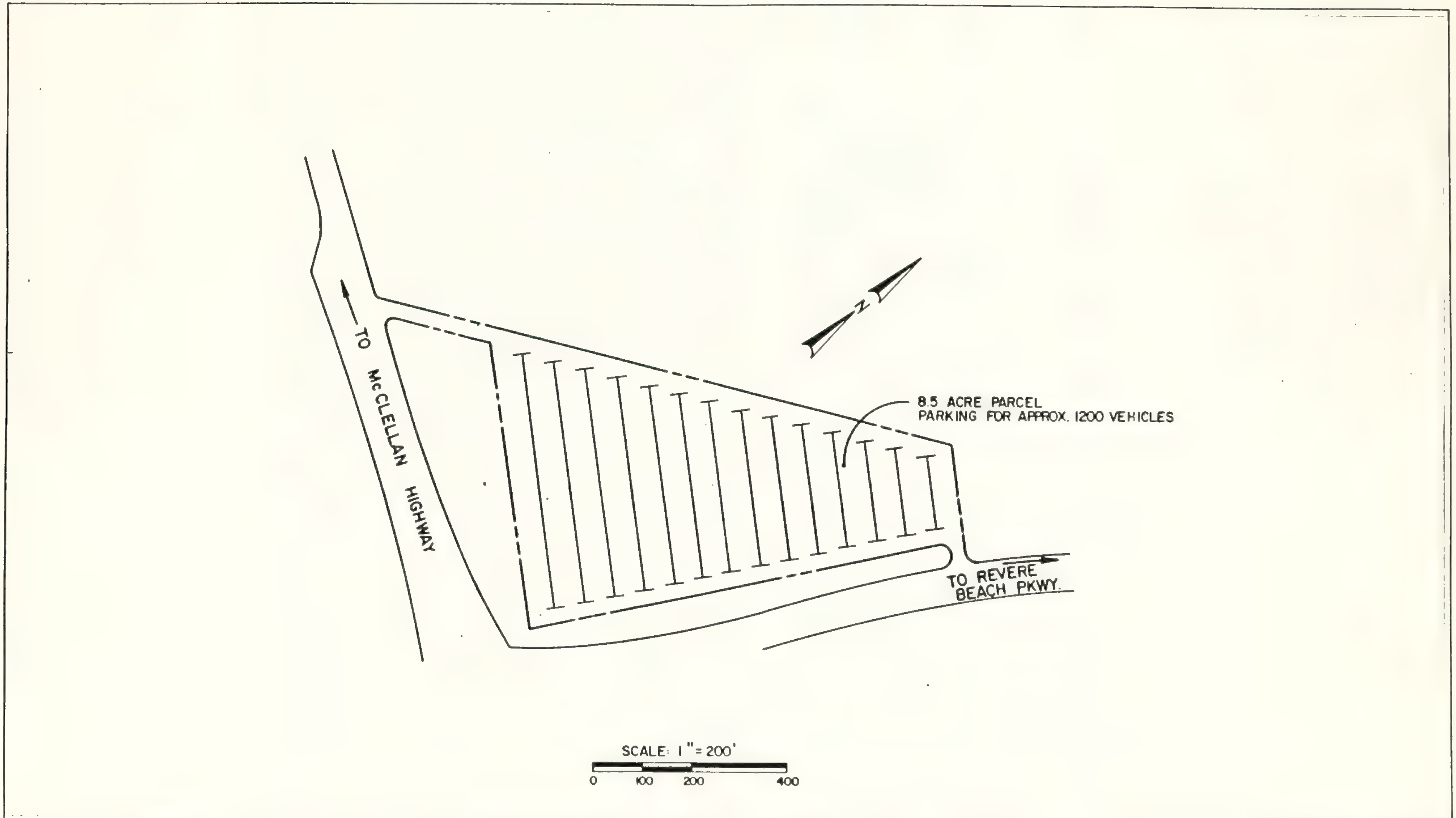
Orient Heights to the south. However, the location of the residences are on a slope setback approximately 300 feet from the proposed parking site. In terms of site use, this area would be minimally impacted by the utilization of a portion of the property as a satellite parking facility.

The site meets the criteria established for a satellite parking facility, with the exception of distance to public transportation. Direct access to the highway (Route 145 and 1A) is available, and compatibility with existing and abutting uses is met. Satellite parking at this location would also be compatible with the plans of the owner, Belle Isle Associates. A letter of interest in providing land for parking was secured from preliminary contact with the owner (see Appendix 1). Overall, the number of potential spaces would be 1,234 (see Figure 3). Since parking is currently located on the site, costs for improvements would be low.

The bus route to Deer Island would access the Suffolk Downs private access road, which exits on Route 145. Under this scenario, travel through residential areas in Boston is not required. Construction worker access to the site will occur via McClellan Highway (Route 1A) or Route 145. Southbound travel on Route 1A allows a left turn into the Suffolk Downs access road, however the intersection is unsignaled and turns must be made with caution due to northbound vehicles. The site offers poor access to public transportation via bus. Route 120, which travels through Orient Heights to Maverick Station, runs over 2000 feet from Suffolk Downs. However, the construction workers may be able to use the Beachmont MBTA station, off of Route 145.

<u>MDC Property at Ocean Avenue</u>

The Metropolitan District Commission (MDC) owns approximately 4.5 acres of land in Revere at the corner of Ocean Avenue and Revere Street. Existing parking for the Wonderland Station on the Blue Line borders the property on



PROPOSED PARKING LAYOUT

SUFFOLK DOWNS

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Fig 3

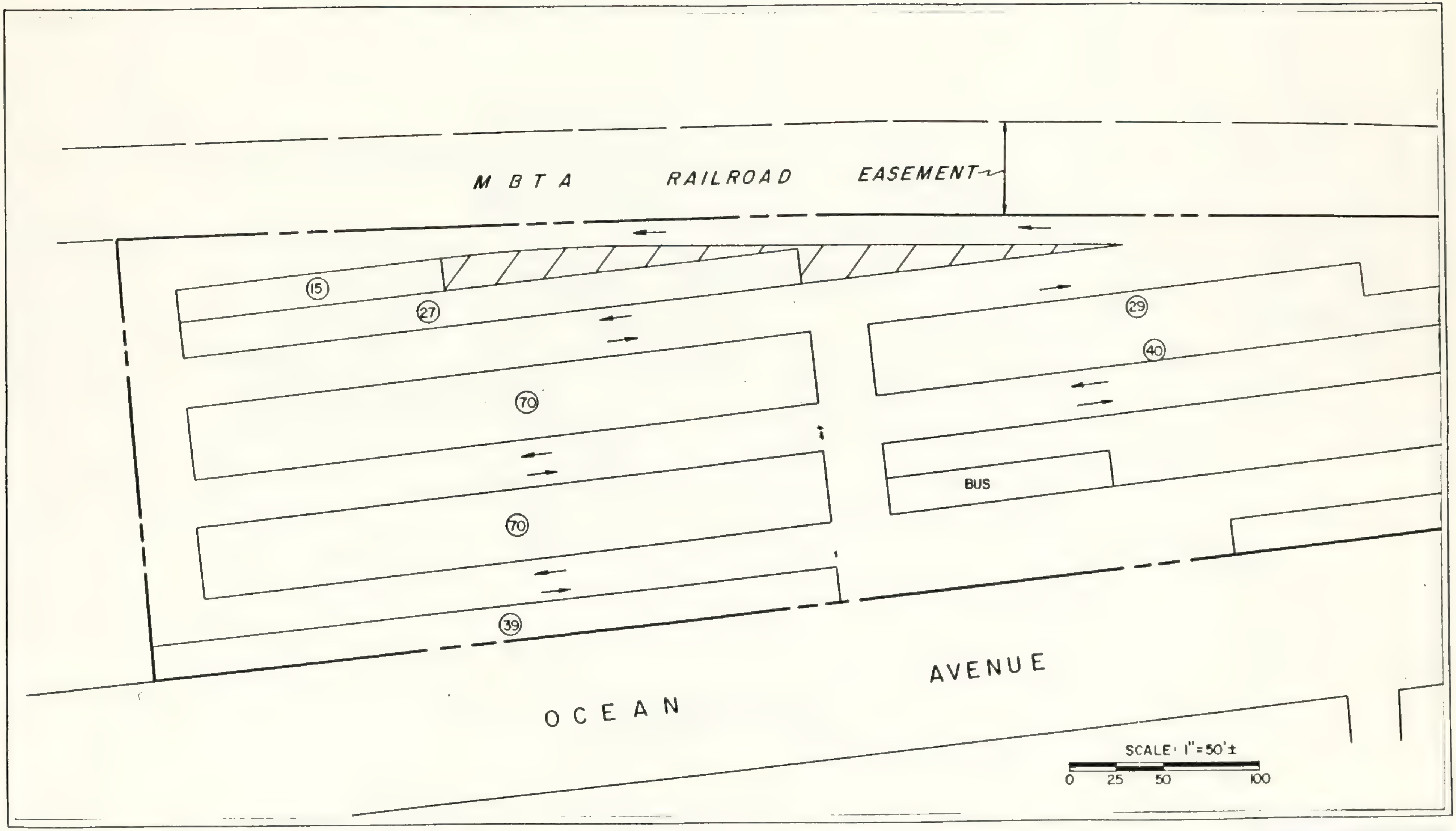
Horizontal Scale in feet AS SHOWN

the south and Revere Street borders on the north. At this location, Ocean Avenue is zoned as a High Rise, Mixed Use RC2 district.

Ocean Avenue forms the eastern border of the MDC property, and provides the roadway access into the site. The west border consists of an embankment which slopes up to Sachem Street, a residential street. The site is paved, however, it is not striped for parking use. Though mostly vacant on weekdays, the MDC requires the property for summer weekend parking for beach patrons. Total parking accommodated could be about 500 spaces at grade, while 800 spaces could be provided via structured parking (see Figure 4A and 4B).

The MDC property meets the majority of the criteria for a satellite parking facility. Due to natural site constraints, a structured parking arrangement at this location may be necessary to accommodate the necessary spaces for satellite parking. The site is one of the closest to Deer Island, and currently serves as overflow parking for the MDC. The use of the property for satellite parking would be compatible with abutting uses. No schools, hospitals, libraries or churches are in the immediate vicinity of the site. Construction worker access to the site would be possible via automobile as well as public transportation at Wonderland Station. Preliminary contact with the MDC resulted in a letter of interest regarding a possible joint venture between the two public entities (MDC and MWRA) (see Appendix 1).

Ocean Avenue, though not a numbered highway, provides a direct route to Winthrop and Deer Island. Though some residences (i.e. oceanfront condominiums) are located on Ocean Avenue, the road is well travelled and bus travel is allowed.



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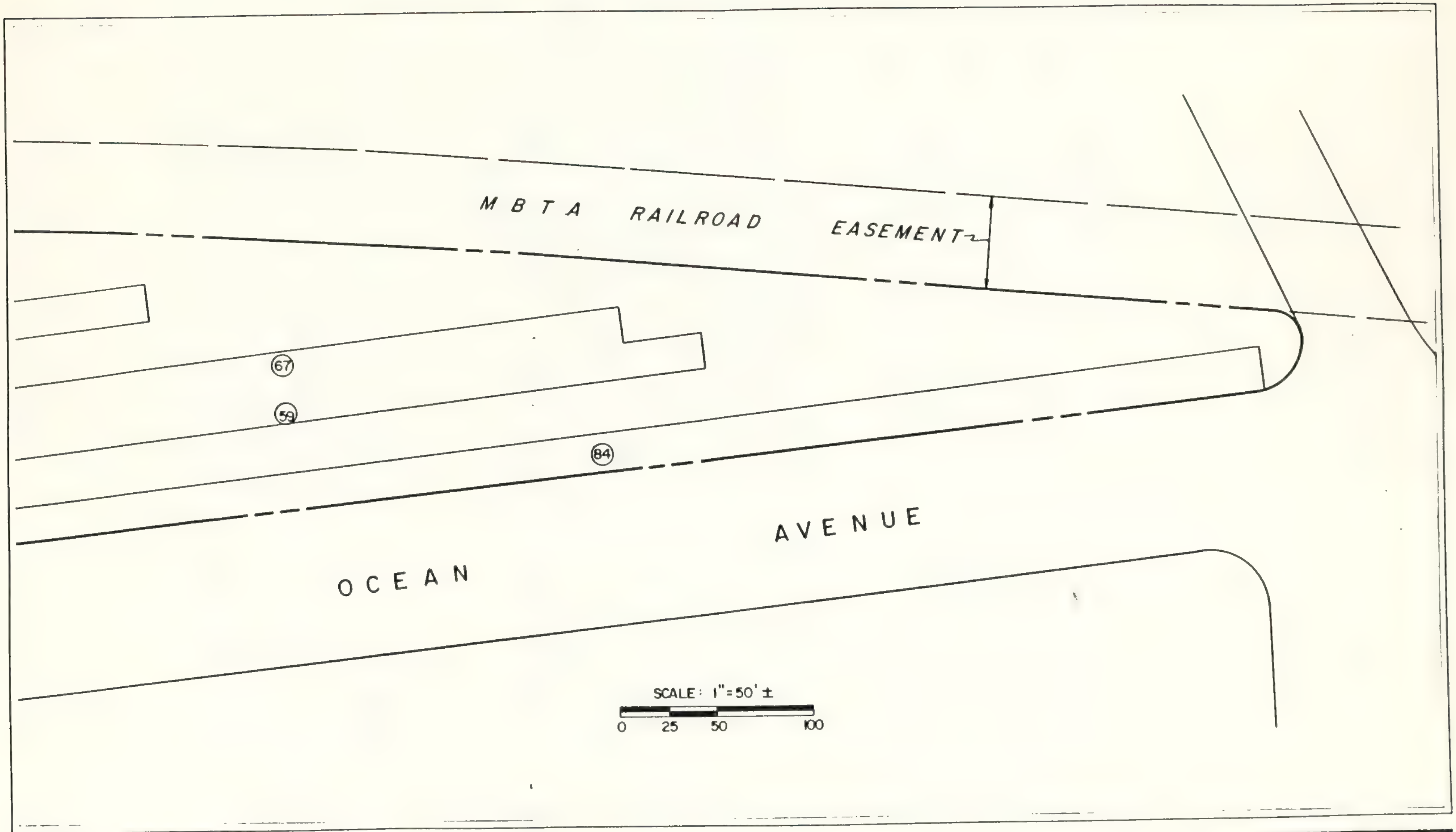
PROPOSED PARKING LAYOUT

Fig 4A

MDC LAND ON OCEAN AVENUE, REVERE (1 OF 2)

Horizontal Scale in Feet AS SHOWN



PROPOSED PARKING LAYOUT

The BSC Group

Fig 4B

MDC LAND ON OCEAN AVENUE, REVERE (2 OF 2)

AS SHOWN

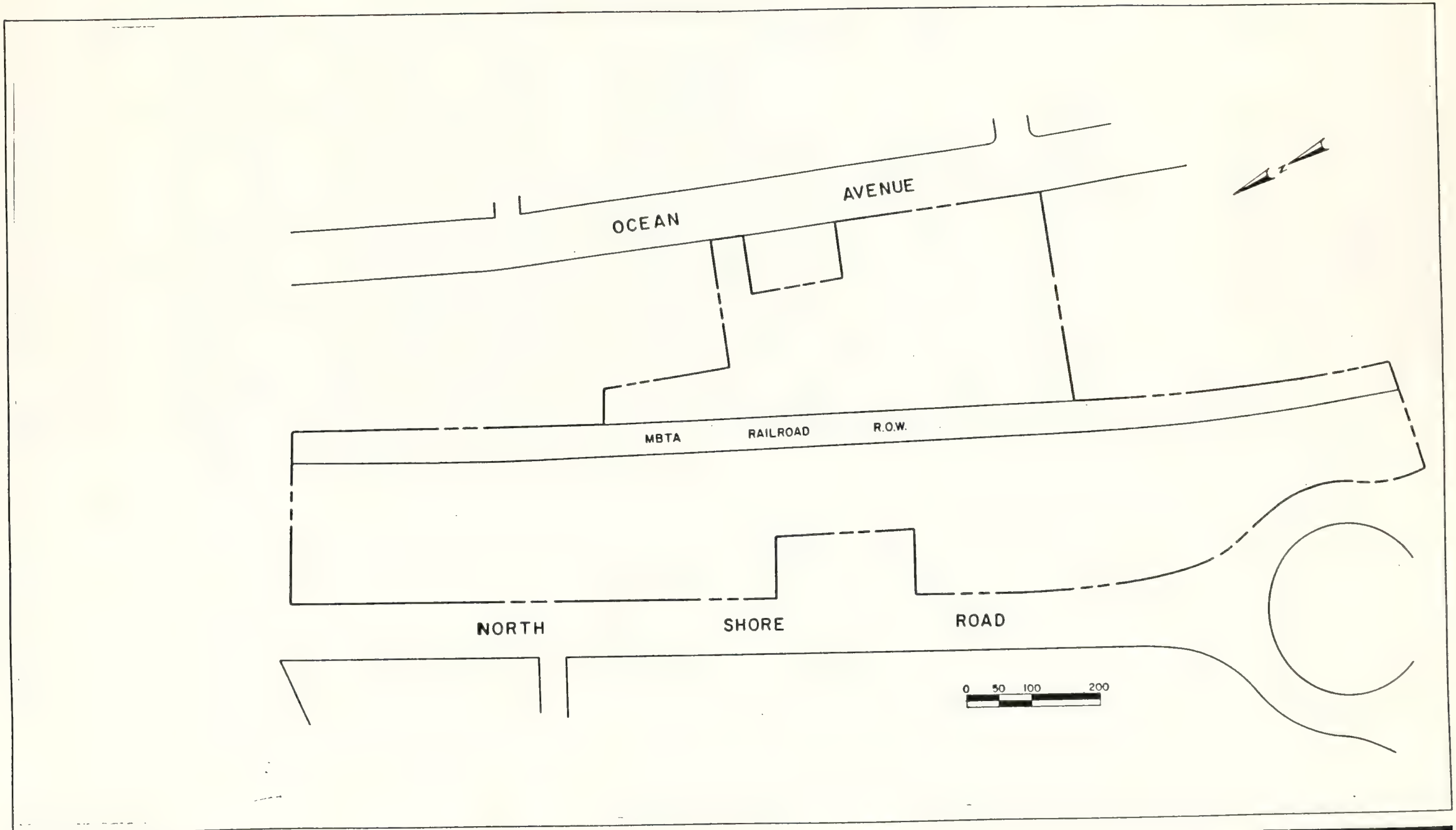
Wonderland MBTA Parking

The MBTA owns approximately 3.6 acres on the Revere Beach Parkway (North Shore Road) north of Butler Circle for parking for the Wonderland MBTA station. The site, zoned High Rise Mixed Use RC2, contains the Wonderland station and the MBTA railroad tracks. The Wonderland Ballroom abuts the site. Wonderland Park is across the Revere Beach Parkway. The MBTA has expressed interest in a joint venture with MWRA for a structured parking facility at this location (see Appendix 1).

As a satellite parking site, the property meets the criteria of compatibility with the existing and abutting uses. In a structured parking arrangement, it is estimated that 800 parking spaces could be accommodated (see Figure 5). Excellent access to the Wonderland MBTA station is available for construction worker access to the site. Transportation to Deer Island would occur via North Shore Road and Ocean Avenue. Leaving the site, via Butler Circle, buses would proceed south on North Shore Road and turn left on Beach Street. The route would turn right onto Ocean Avenue, which leads directly to Eliot Circle. The use of this route allows direct access to Deer Island without requiring travel on the residential and narrow portion of North Shore Road below Beach Street.

Beachmont MBTA Parking

The Beachmont parking lot in Revere, under the ownership of the Massachusetts Bay Transportation Authority (MBTA), is directly adjacent to the Beachmont Station on the Blue Line. The lot is an at-grade surface lot, located on the west side of the Blue Line tracks. The parcel is roughly triangular in shape, bordered by Winthrop Avenue, Washburn Avenue, and the Revere Beach Parkway (Route 145), a well-travelled artery. One residence directly abuts the parking lot. Surrounding uses also consist of: (1) the Suffolk Downs Park



PROPOSED SITE FOR STRUCTURED PARKING

WONDERLAND MBTA STATION, REVERE

The BSC Group

Fig 5

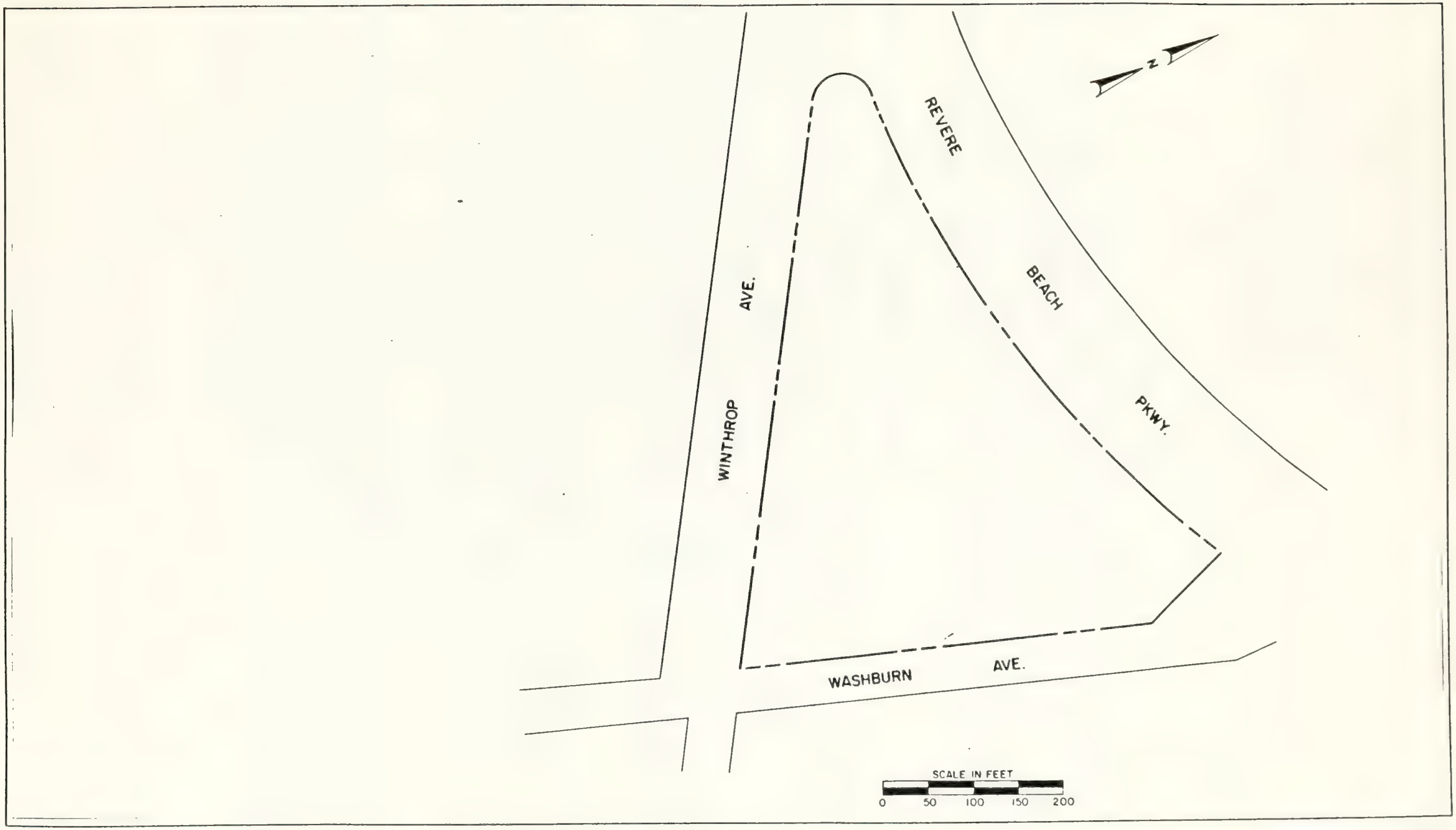
Horizontal Scale in Feet AS SHOWN

stables located across Winthrop Avenue, (2) commercial and retail establishments on Winthrop Avenue and State Road, and (3) business establishments on the Revere Beach Parkway. The site is zoned General Residence RB.

The existing parking lot, approximately 3.5 acres in size, contains 394 spaces. It is presently filled at 100 percent capacity. Parking charges are $1.00 per car per day and are collected by on-site personnel at the entrance to the lot. In the evaluation of this site for a satellite parking facility, it is clear that structured parking would be required to meet peak construction worker demand and existing parking needs. Temporary disruption to MBTA commuters that park at this site would occur during construction of a new facility. Costs for the development of a structured facility will be high, however, a total of 800 spaces would be available for bus transportation of construction workers to Deer Island and the future long-term use of the MBTA (see Figure 6). The MBTA has submitted a letter of interest regarding a possible joint venture for the use of the site for this purpose (see Appendix 1).

In terms of the site selection criteria, the Beachmont parking lot is the closest site to Deer Island. The site is currently used for parking; thus, the expansion of the number of parking spaces would be compatible with present uses. Abutting uses are compatible with the proposed use of the site as a satellite parking facility. The site has excellent access to public transportation at the Beachmont Station, though it is likely that construction workers will arrive at the site via automobile. The lot entrance is within 500 feet of the Revere Beach Parkway.

The access routes to and from Deer Island may vary slightly for this site, because of the potential traffic delay in making left turns at the Winthrop Avenue/State Road intersection. Though the intersection is signalled, left turns, particularly during peak hours would be impeded by



PROPOSED SITE FOR STRUCTURED PARKING

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Fig 6

BEACHMONT MBTA STATION, REVERE

Horizontal Scale in Feet AS SHOWN

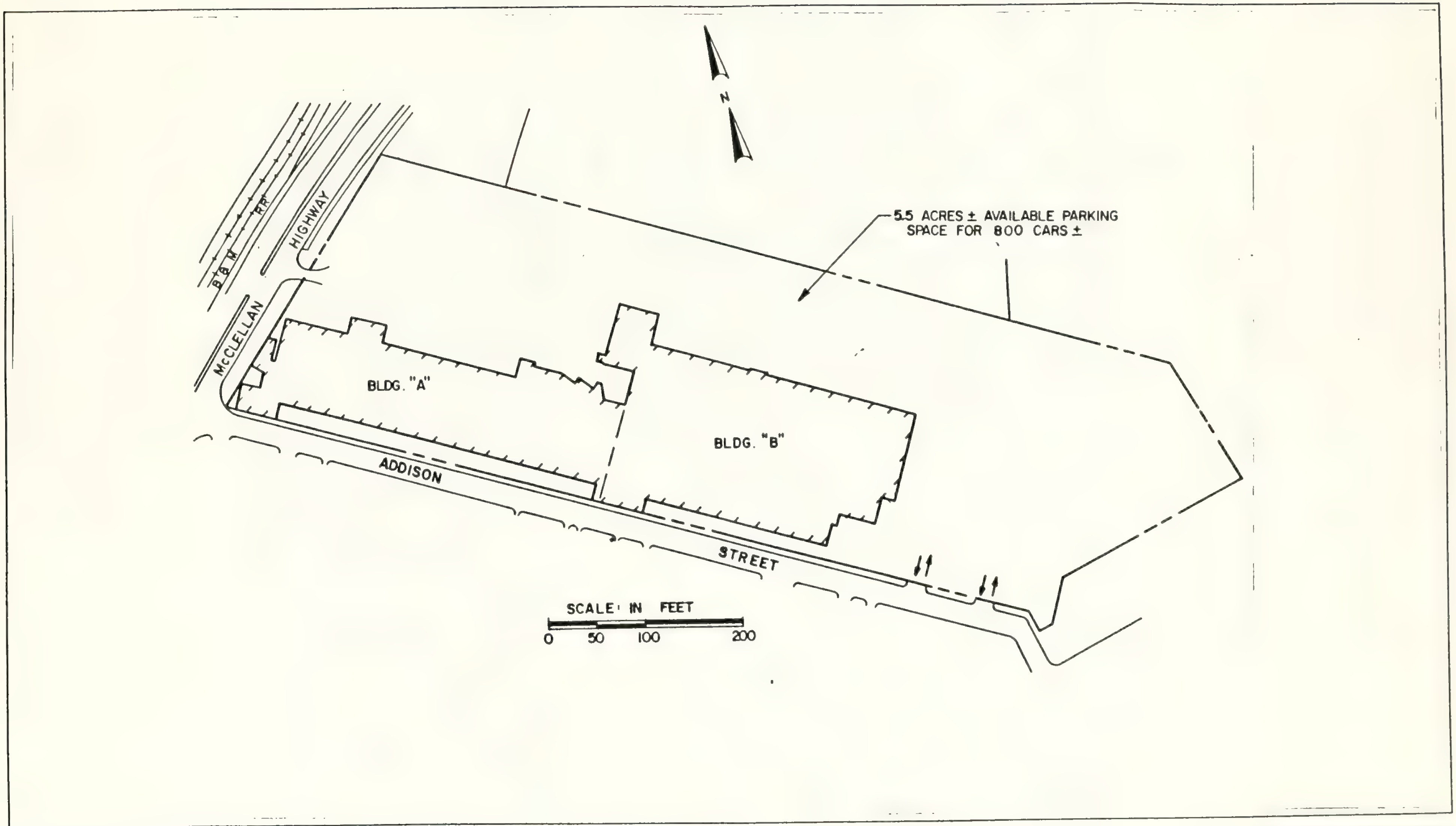
restrictive turning radii for buses. Use of Winthrop Avenue for bus access was considered less desirable due to adjacent commercial and residential areas. Thus, trips to Deer Island will proceed northwest on Winthrop Avenue and turn right onto the Revere Beach Parkway. Trips from Deer Island will return via the underpass under Route 145 and merge with State Road. A right turn is then required from State Road onto Winthrop Avenue.

Towle Property/144 Addison Street

Approximately 14 acres is available for lease at the corner of Addison Street and the McClellan Highway in East Boston. Formerly the Towle Warehouse, the site contains two buildings, a garage, and primarily paved open space. Approximately 1,100 parking spaces can be accommodated. Of this total, it is estimated that 800 spaces could be provided for satellite parking (see Figure 7). The number of spaces available for satellite parking will also depend on zoning requirements for the site, which will necessitate input from the City of Boston.

The site is bordered by McClellan Highway to the west and existing industrial uses to the north. A multi-family housing development, Brandywine Village, directly abuts the rear of the site. Addison Street contains a mix of both residential and business uses. Additional housing is located in the neighborhood to the south of Addison Street.

The major route providing worker access to the site would be McClellan Highway. In terms of selecting a bus route to the property, however, the use of the McClellan Highway was eliminated from consideration because of the difficulty of access from Addison Street to the highway. The intersection of these two streets is unsignaled and does not provide a curb cut for southbound vehicles travelling on the McClellan Highway to enter Addison Street.



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SITE PLAN

Fig 7

TOWLE PROPERTY, EAST BOSTON

Horizontal Scale in Feet AS SHOWN

In terms of ease of access to the site, the preferable alternative would be to exit from the rear of the property onto Saratoga Street. Buses would then proceed on Saratoga Street to Bennington Street. Bennington Street provides a direct route to Eliot Circle in Revere. Though the portion of this route in Revere is amenable to a satellite parking bus route, the route consists of travel through residential areas of East Boston. Saratoga Street is a narrow road. Bennington Street serves as a MBTA bus route between Orient Heights and Maverick stations. The intersection of Saratoga Street and Bennington Street is a major intersection with a long traffic signal cycle. This intersection would require traffic engineering analysis to assess potential impacts. Another option for access to the site is via a paved roadway that traverses the Ramada Inn property in an easterly direction until its junction with Boardman Street and then onto Bennington Street. This access option would require use of an existing easement or negotiation for a new easement. The MWRA would pursue such an option in future discussions with the site owner.

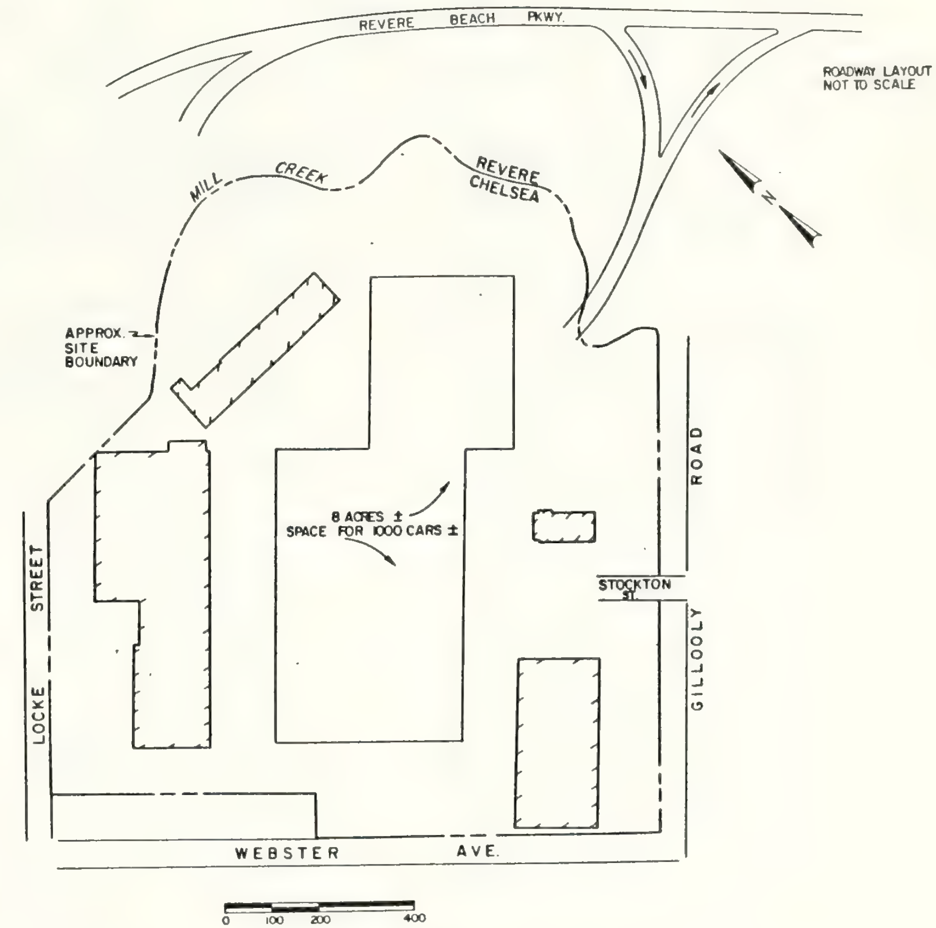
Parkway Plaza

Parkway Plaza occupies approximately 35 acres next to the Revere Beach Parkway (Route 16) at Mill Creek in Chelsea. The plaza is located in an SC district (Shopping Center). Major retail uses include Bradlees and a Stop and Shop supermarket. Smaller retail businesses are located in an adjacent plaza. The majority of the site is used for parking or consists of open space; an estimate of 5 acres of the site contains buildings. The entire site is owned by Patrick Glynn with the exception of Martignetti Liquors (1020 Revere Beach Parkway), 121 Webster Avenue (formerly the carpet warehouse), owned by Carl and Rita Barron, and a one-half acre parcel, owned by James and Robert Green (dba U.S. Realty Exchange) next to Mill Creek.

The site is bounded by Locke Street and the Revere Beach Parkway to the northwest, Webster Avenue to the southwest, Gillooly and Stockton Street to the southeast, and the Mill Creek and Revere Beach Parkway to the northeast. The bordering roads, with the exception of the Revere Beach Parkway, are primarily residential. However, Stockton Street intersects with Broadway, which is zoned for business. A mix of residential and commercial uses are found on Broadway. Locke Street contains some residences owned by the Chelsea Housing Authority. "Chelsea Creek: A Plan for Transition", completed in March 1986 by the City of Chelsea, identified Parkway Plaza as a site with potential reuse for planned development (i.e. office, residential, and hotel space). The need for improved access, interior circulation patterns and landscaping at this location was also discussed in this report.

The site meets the majority of the criteria for a satellite parking facility. Based on preliminary contact with the owner, approximately 5.5 acres (see Figure 8) could be made available within Parkway Plaza to accommodate at least 800 satellite parking spaces (see Appendix 1). Satellite parking on the site is compatible with present uses and is of substantial size so as not to impact residential abuttors. Public transportation access to the site for the construction workers would be on Bus Route 116 or 117 at the intersection of Broadway and Webster Street, approximately 1500 to 2000 feet from the site. These bus routes run to Maverick Station on the Blue Line. The cost of improvements on existing parking areas would be low.

Trips to Deer Island would exit the site directly via the Revere Beach Parkway, thus avoiding residential impact. However, travelling west on the Revere Beach Parkway, direct access back to the site is not available. The bus trip from Deer Island would require an exit at Broadway (Route 107), a mixed residential and commercial area.



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SITE PLAN WITH PROPOSED PARKING

Fig 8

PARKWAY PLAZA, CHELSEA

Horizontal Scale in Feet AS SHOWN

Two alternatives, both at signalled intersections, are available to access the site from Broadway. One option involves turning right onto Stockton Street from Broadway. The distance travelled through the residential area on Stockton Street would be slightly over 500 feet before entering Parkway Plaza. The second option provides access to the site via Webster Avenue, which forms the southwest border of the site. The bus route would travel on Broadway and turn right on Webster Avenue. Though Webster Avenue is more well-travelled than Stockton Street, the route requires a slightly longer distance for the bus trip through the mixed residential and commercial areas along Broadway and Webster Avenue.

Eastern Minerals

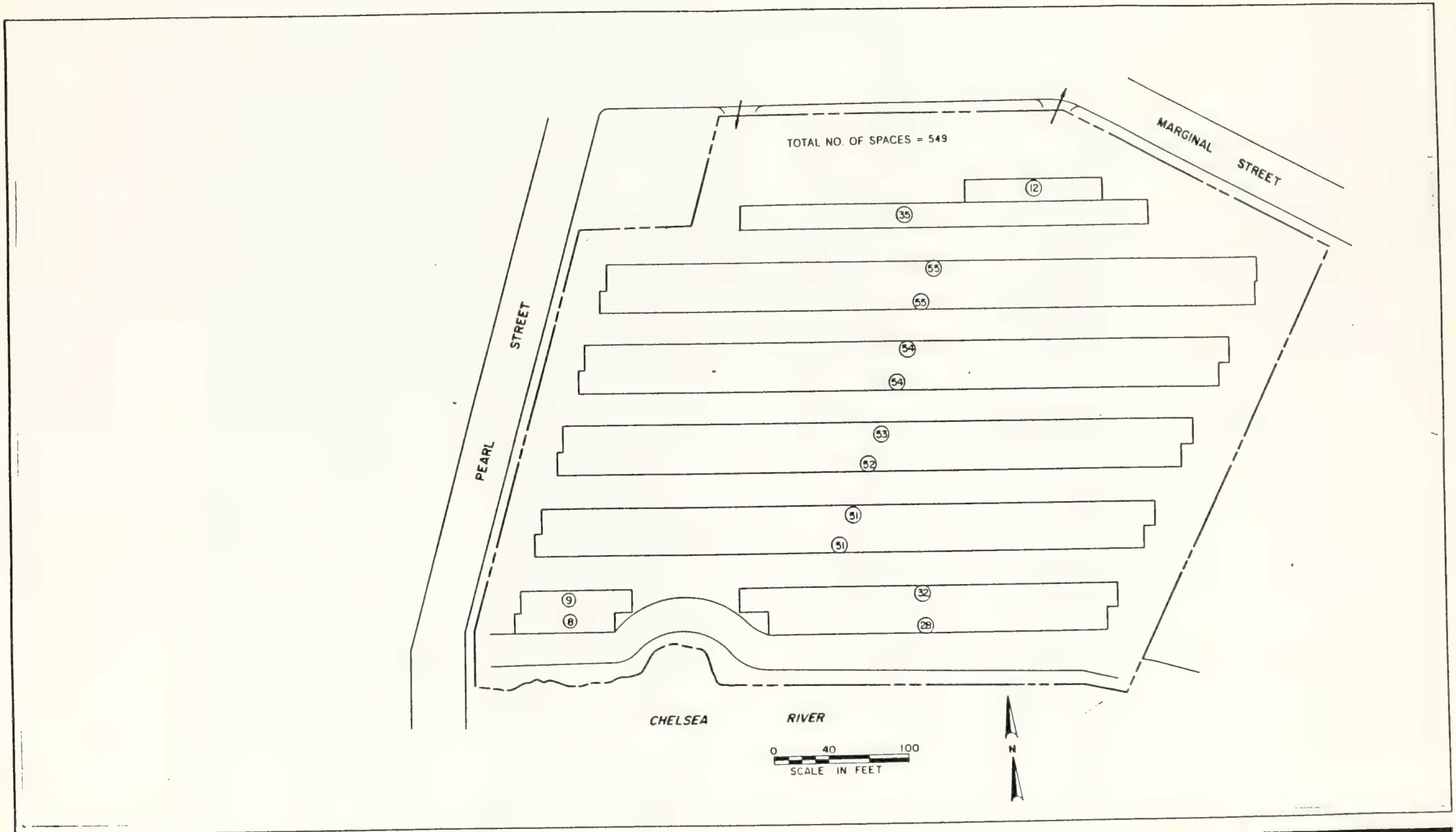
Located at the corner of Pearl Street and Marginal Street in Chelsea, a 4.7 acre parcel is controlled by David and Daniel Mahoney (SMP Trust). The site is zoned in an Industrial Waterfront district; prior use of the property was for the storage of road salt. The site is bordered by Pearl Street to the west, Marginal Street to the north, the Chelsea Creek to the south, and abutting industrial uses (i.e. Quincy Oil Company) along Marginal Street to the east. The 38,000 square foot Quincy Oil parcel, next to and owned by Eastern Minerals, is adjacent to Texaco Inc., along the Chelsea Creek. Currently vacant, the property was formerly used for oil storage and distribution facilities.

Other nearby uses are a gas station and commercial establishments further north on Pearl Street. The property is fenced with a landscaped berm along the Marginal Street border. The interior of the site contains a paved area, amenable for parking purposes. "Chelsea Creek: A Plan for Transition" recommends the upgrading of Marginal Street and Eastern Avenue area. In reference to this site, the Chelsea Creek report proposes the possible rezoning to a Waterfront Planned Development District and the re-use of the site for commercial, residential, and office space.

The potential satellite parking capacity at this location would be 549 spaces (see Figure 9). Compatibility of temporary satellite parking with existing and abutting uses is met at this location. Construction worker access to the site is available via Route 1, approximately 1,200 feet from the site, or McClellan Highway, approximately one mile from the site. Public transportation is available at the corner of Marginal and Pearl Street via Bus Route 112, 116, or 117, which provide transportation to Maverick Station on the Blue Line. The site is not currently used for parking, but offers low improvement costs due to open space on the site.

Conversations with the owner indicated the possibility for a lease arrangement on the site for satellite parking purposes. Should such an arrangement be worked out, the MWRA would coordinate its activities at this site with City officials in a cooperative venture. The MWRA understands there is ongoing litigation between the owner and the City of Chelsea regarding this site. When resolved, the MWRA will accommodate the City on issues of importance. To meet the peak demand for construction workers in 1992 and 1993, the Quincy Oil property adjacent to the site would be considered for negotiation between the owners and the MWRA to provide 127 additional spaces for a total of 676 spaces. The shortfall at this site could be addressed in conjunction with other satellite parking sites or water transport ferry sites.

The site is the longest distance to and from Deer Island. Marginal Street offers convenient access entering and exiting the property. The street is sufficiently wide for bus travel. The proposed bus route to Deer Island would be to travel north on Eastern Avenue until its intersection with Broadway. Eastern Avenue is primarily industrial. Near its intersection with Broadway, business, retail, and residential uses are common. Buses would travel on Broadway to the point where it intersects with the Revere Beach Parkway, then follow the Revere Beach Parkway to Route 145



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PROPOSED PARKING LAYOUT

Fig 9

EASTERN MINERALS SITE, CHELSEA

Horizontal Scale in Feet AS SHOWN

to Eliot Circle. The return route from Deer Island would be via the Revere Beach Parkway exiting at Route 107 (Broadway) in Chelsea and following the previously described route to Deer Island south on Eastern Avenue. Traffic analysis would be required for the route impacts in the City of Chelsea.

Sites Eliminated

The following section describes the sites evaluated but not recommended for implementation with a statement of the factors which caused those sites to be eliminated. Of these additional sites considered, 1 was located in Boston, 2 were located in Revere, and 6 were located in Chelsea.

345 McClellan Highway

Owned by the Edward McCormack Trust, 345 McClellan Highway consists of approximately six acres, zoned Industrial 2, with frontage on the McClellan Highway in East Boston. Avis Rent-A-Car is located directly to the northeast of the property and the Ramada Inn is located to the southwest. An access road to the Ramada Inn, located to the rear of the property, separates the site from a public multi-family housing development. The access road, containing two speed bumps, leads to Boardman Street; which, in turn, feeds into the McClellan Highway at a signalled intersection.

Originally a part of the Boston Naval Fuel Annex, the site is currently vacant. As a remnant of its former military use, the property contained two underground oil tanks, each with a capacity of more than a million gallons, and an underground piping system. One oil tank had been previously pumped, cleaned, and filled; the other underground tank is currently being pumped, cleaned, and filled under the supervision of the Department of Environmental Quality Engineering (DEQE). The work at this site should be completed by the summer of 1988. The site is currently available for lease.

The major factors contributing to the elimination of this site include access to the site from McClellan Highway. Vehicles travelling southbound along the McClellan Highway are prohibited from left turns into the property due to the absence of curb cuts off of the highway. Thus, the travel distance on the return trip is increased an extra 1.3 miles. Back access to the McClellan Highway via Boardman Street would require an arrangement with the Ramada Inn for bus/worker access along this roadway or the exercising of an easement along the Avis property to the site.

Wonderland Parking Lot/Westwood Group

Wonderland Park, a greyhound racetrack, occupies nearly 40 acres of land on Route 16 in Revere. The property contains a clubhouse and track, as well as parking on both sides of the Revere Beach Parkway. Across the street, the Wonderland MBTA Station on the Blue Line provide excellent access to Wonderland Park.

Satellite parking at this site is compatible with existing and abutting uses; however, at the present time, satellite parking at this location is not compatible with the plans of the owners (the Westwood Group). A proposed bus route from this site could follow a route, leaving Butler Circle and proceeding south on North Shore Road to Beach Street. The route would then access Ocean Avenue which leads directly to Eliot Circle, and, subsequently, Deer Island.

An alternative to avoid any travel on North Shore Road would be to proceed north on the Revere Beach Parkway, turn right at Revere Street, and proceed south on Ocean Avenue, adding approximately one mile to the trip. The consideration of a route travelling south on the Revere Beach Parkway to Bell Circle and east on Route 145 was eliminated because of anticipated traffic problems in the heavily-travelled Bell Circle.

MDC Property at Sales Creek

The MDC property at Sales Creek in Revere is a 3.2 acre vacant parcel on the Revere Beach Parkway. Despite its convenient location on the Parkway, the property does not offer close proximity to public transportation. The area is in mixed use; one of the abutting uses of the property is the Pass Law Offices at 412 Revere Beach Parkway. Other surrounding land uses include the Pratt Place Apartments, a three-story residential apartment complex and the Sales Creek. The site contains wetlands adjacent to the Sales Creek. Due to the undeveloped conditions of the site, the cost of improvements relative to other sites that have parking would be higher.

The major factor contributing to the elimination of the site is the ease of worker access. Westbound travel on Route 145 during the return trip from Deer Island does not provide convenient access to the site. Buses would be required to make a U-Turn at the intersection of Route 145 and Route 1A. The intersection allows U-Turns, but the turning radius would be restrictive to buses. In addition, the site does not offer access from the rear of the property over the Sales Creek. If such a route were possible, the site would be accessible to the private access roads on Suffolk Downs and Route 145 in Revere.

270 Central Avenue

A 3.4 acre, undeveloped parcel is located at the corner of Eastern Avenue and Central Avenue in Chelsea. The site is located in a residentially zoned district, however, no residential abuttors immediately border the site. The Mill Creek condominiums are being developed to the north of the site on Cottage Street. The character of the area along Eastern Avenue is composed of business or industrial uses. Trips to and from Deer Island would not require travel through residential areas in Chelsea.

The property is available for lease from the owner of the site, M-C Realty and Highway Association. However, Lazarus Development Corporation, which is constructing the Mill Creek condominiums, has a right of first refusal on the use of the property. The Chelsea Creek Plan's development recommendations for this general area include expanded residential areas, light manufacturing, and parks. The property is located within 500 feet of public transportation via Bus Route 112, which runs along Central Avenue between Maverick station and Wellington station.

The site has been ranked lower than other potential sites in the selection criteria for a satellite parking facility due to the cumulative factors of site access and compatibility with the site restrictions (i.e. right of first refusal). The site is located at the intersection of three heavily travelled roadways, Eastern Avenue, Marginal Street, and Central Avenue, where site access is likely to be affected by the high incidence of traffic accidents (Chelsea Creek report).

<u>285 Central Street</u>

M-C Realty II and Highway Association owns the property at 285 Central Avenue in Chelsea, which is located in a residentially zoned district. Overall, the site consists of approximately 33,000 square feet of vacant land; a 10,000 square feet sewer easement on the site was recently acquired by the MWRA. Abutting uses include the MWRA/MDC Chelsea Pump Station and 270 Central Avenue (described above). Oil tanks are located on Marginal Street across from the site. In meeting selection criteria, satellite parking at this location would be compatible with abutting uses.

However, the small size of the parcel (less than one acre) diminishes its viability as a satellite parking site. Approximately 110 spaces could be accommodated at this location, necessitating the use of the site in conjunction

with one or more other parcels to meet construction worker parking needs. As noted with 270 Central Avenue, entering and exiting the site occurs at the intersection of three well-traveled roads, Eastern Avenue, Marginal Street, and Central Avenue.

29 Eastern Avenue (MDC)

The smallest site considered for satellite parking is a 0.6-acre irregularly shaped parcel owned by the Commonwealth of Massachusetts, Metropolitan District Commission. The property, zoned Waterfront, is located at 29 Eastern Avenue in Chelsea, across from both 270 and 285 Central Avenue. A former diner, now the offices of Big T and D Trucking, is situated on the front of the parcel. Miscellaneous trucking equipment is located to the rear of the parcel.

The property is bordered by Marginal Street, the Chelsea Street Bridge, oil storage and distribution facilities at the Northeast Petroleum site, and the Chelsea Creek. Re-use recommendations presented in the Chelsea Creek plan for this area include possible rezoning with the continuation of the tank farms as a non-conforming use.

The factors which contributed to the elimination of this site were its small size and limited capacity to provide satellite parking. Approximately 70 spaces would be available at this location. As a result, the combination of this site with other parcels would be required. The site is also occupied by Big T and D Trucking.

Cabot/South Side/229 Marginal Street

The former Cabot Paint property was considered as a potential site for satellite parking. Nearly 6.4 acres is located at 229 Marginal Street in Chelsea, of which 5.1 acres is available as open space. The site was occupied by manufacturing and office buildings, above ground storage

tanks, paved parking areas, and vacant land. 740 parking spaces could be accommodated on the undeveloped portion of the site. No difficulty exists with regard to bus entrances and exits to and from Marginal Street.

Currently vacant, the site had formerly been used for paint manufacturing and is zoned in a district designated for waterfront use. The site has waterfront access to the Chelsea Creek. Industrial uses abut the site, including Northeast Petroleum and Texaco Corporation. The site ceased operation as a stain manufacturing facility in 1985; however, a file search at the DEQE revealed information on the release of oil/hazardous material during the use of the property.

Positive features of the property are its size and compatibility of proposed satellite parking with existing and abutting uses. Access from Marginal Street is adequate, both entering and exiting the site. However, the site was eliminated from consideration due to the history of hazardous materials on the property, as of yet still unresolved. Under Massachusetts Law, Chapter 21E, DEQE has issued a consent order to the owner defining clean-up needed at the site. Clean-up costs are expected to be high. Should the contamination issues be resolved, the site is suitable for consideration as a satellite parking facility.

Cabot/North Side

Samuel Cabot Inc. owns an additional 1.32 acres of vacant land across from 229 Marginal Street at the intersection of Marginal and Willow Street. The site is zoned waterfront industrial. Marginal Street, as noted for the Samuel Cabot property at 229 Marginal Street, would provide adequate access for bus transportation. The total number of parking spaces anticipated at this location would be 192 spaces.

The major factor contributing to the elimination of the site from potential areas for satellite parking is the size of the parcel. Selection of smaller sites necessitates the use of one or more sites to meet construction worker parking demand.

250 Marginal Street

At the corner of Willow Street and Marginal Street in Chelsea, 1.7 acres is owned by the Biltrite Corporation. The Biltrite Corporation was involved in the manufacturing of plastic and rubber soles for shoes. The property considered for satellite parking is vacant land in an industrial district. Industrial uses make up the majority of land uses in the area; abuttors to the north include Caleb Brett USA and Nancy Sales Inc. This site, like the majority of parcels considered on Marginal Street in Chelsea, meets compatibility criteria for satellite parking. As noted with the parcels owned by Samuel Cabot, access from the location is adequate for exiting and entering on Marginal Street. The small size of the property eliminates consideration for a satellite parking facility.

6.0 BUS OPERATING PLAN

Logistics

The bus transport of workers to Deer Island will be dependent upon shift schedules as well as the number of workers to be transported to and from the Island. This report assumes the following shift change times:

Shift:	Leaves from Satellite Parking Site(s)	Arrives Deer Island	Leaves Deer Island	Arrives Satellite Parking Site(s)
1	6:00AM	6:30AM	2:30PM	3:00PM
2	3:30PM	4:00PM	12:00AM	12:30AM
3	10:30PM	11:00PM	5:00AM	5:30AM

Given this shift change schedule and the worker profile in Table 1, transport of 926 workers by bus per day in the year 1992 would occur in the following manner:

Shift	# of workers to be bused	# of buses (assumes 40 workers per bus)*
1	611	16
2	158	4
3	157	4
Total	926	24

*Estimate from Rapid Transit, Inc. based on bus capacity

Applying these buses to the bus routes described later in this section for the short-listed sites, a fleet of 16 buses will be needed to transport 611 workers for the first shift. The round trip travel time ranging from 22 to 45 minutes will most likely preclude buses making multiple trips to deliver workers to Deer Island (see Table 3).

If there is overlap between shifts then the transport of workers by bus in 1992 would be as follows:

	# of workers to be bused	# of buses (assumes 40 workers per bus)*
Shifts 1 and 2		
Overlap	769	20
3rd Shift	157	4
Total	926	24
	or	
Shifts 1 and 3		
Overlap	768	20
2nd Shift	158	4
Total	926	24

*Estimate from Rapid Transit, Inc. based on bus capacity

This shift overlap will increase the number of parking spaces required at satellite parking sites not the number of workers to be bused. Without shift overlap between the first shift and either the beginning of the second shift and end of the third shift, 611 spaces would be required in the peak year of 1992, while 769 spaces would be required with shift overlap. If there is no overlap, this will result in the smallest number of cars, workers and buses required at a site(s) and will also avoid workers commuting during peak hours (a major assumption of the water transportation facilities assessment).

TABLE 3 SATELLITE PARKING SITES - BUS TRAVEL TIMES TO DEER ISLAND

	DISTANCE TO D.I. (miles)	TRAVEL TIME (min.)	ROUND TRIP TIME (min.)	ROUND TRIP TIME (hr.)	FACTOR AS TIME TO D.I. (Beachmont Base Case)
REVERE SITES					
Beachmont	4.4	11.0	22	0.37	1.00
MDC Sales Creek	5.2	13.0	26	0.43	1.18
MDC Ocean Ave.	5.1	13.5	27	0.45	1.23
Wonderland(Westwood)	6.0	15.0	30	0.50	1.36
MBTA Wonderland	5.1	12.5	25	0.42	1.14
CHELSEA SITES					
Parkway Plaza	6.3	16.5	33	0.55	1.50
270 Central Ave.	7.1	20.5	41	0.68	1.86
285 Central Ave.	7.1	20.5	41	0.68	1.86
29 Eastern Ave.	7.1	20.5	41	0.68	1.86
Cabot (North)	7.4	21.5	43	0.72	1.95
Biltrite	7.4	21.5	43	0.72	1.95
Cabot (South)	7.4	21.5	43	0.72	1.95
Eastern Mineral	7.9	22.5	45	0.75	2.05
EAST BOSTON SITES					
Suffolk Downs	5.3	12.5	25	0.42	1.14
345 McClellan Highway	7.4	16.0	32	0.53	1.45
Towle Site/Addison St.	6.1	15.5	31	0.52	1.41

Bus Operating Costs

MWRA will contract with a bus service provider for the transport of workers from the satellite parking sites to Deer Island. Operating costs will depend upon variables yet to be finalized (i.e. type of vehicle used, distance from site(s) to Deer Island).

The figure of $40.00 to $45.00 per vehicle-hour is used for this estimate, assuming a two hour minimum each time a vehicle is used. This figure is based on an estimate from Rapid Transit, Inc., the contractor currently providing bus service to the Town of Winthrop. Using this estimate and assuming bus operation 260 days per year, the cost for the 24 buses, at peak worker demand in 1992, would be $1,497,000 to $1,684,800 per year.

Supervision

The transport of workers by bus will be overseen on a daily basis by the MWRA or its designees to ensure that the contractor providing the bus transportation meets daily performance requirements for the life of the Deer Island project. Such supervision will be the basis for performance reviews to evaluate the contractor and the logistics of the bus operating plan.

Bus Routes

The bus routes for the seven short-listed sites are described below. For all seven sites, all trips were routed through Eliot Circle in Revere. For the Chelsea and East Boston sites, consideration was given to the use of the Belle Isle Bridge, off of Saratoga Street, in East Boston to enter Winthrop and travel to Deer Island. However, the

residential character, and the narrow roads, were considered less suitable than transportation via Eliot Circle and the Winthrop Parkway.

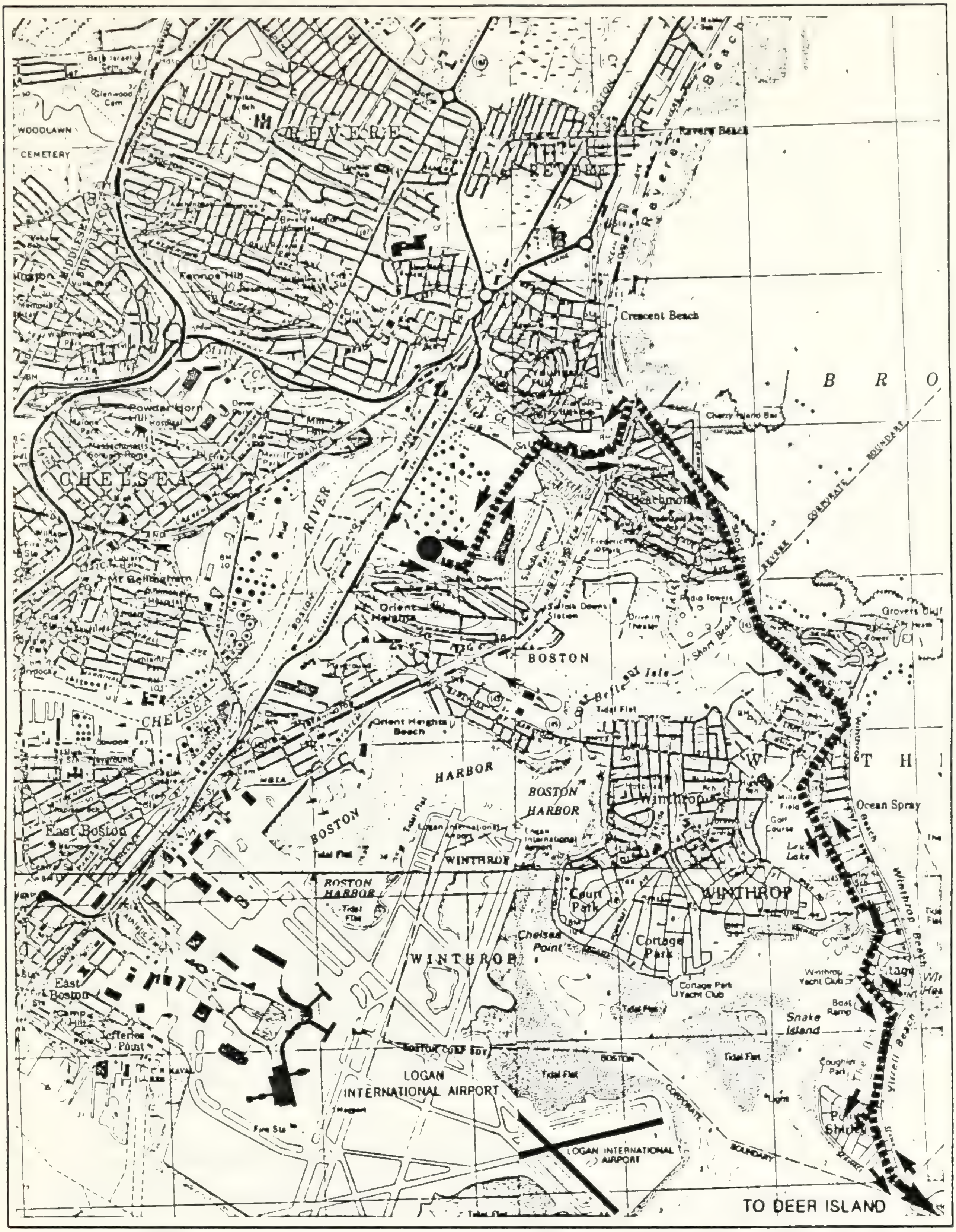
Buses utilize the Belle Isle Bridge, however, future capacity is being considered between the City of Boston and the Massachusetts Department of Public Works regarding posting of the bridge. Additional traffic assessment will be required for this route.

The portion of the trip from Eliot Circle on Route 145 in Revere to Deer Island and back from Deer Island to Eliot Circle follows the identical route. Heading to Deer Island, for example, buses will travel south on the Winthrop Parkway (Route 145). At Washington Avenue, where Route 145 makes a sharp right, the buses will continue south on Shirley Street, following the truck route, to Deer Island. Wherever possible, the routes are designed to avoid residential areas.

<u>Suffolk Downs</u> (See Figure 10)

Transportation from Suffolk Downs to and from Deer Island involves the use of the Suffolk Downs private access road to Route 145. The bus route would follow the internal roadway past the Suffolk Downs clubhouse and exit directly onto Route 145 at a signalled intersection. Following Route 145 east leads directly into Eliot Circle.

Buses from Deer Island would return via the same route, requiring a left turn from Route 145 into Suffolk Downs. This route would save approximately 0.4 mile and 2.5 minutes from the one-way trip to Deer Island over a route utilizing the McClellan Highway.



BUS ROUTE

SUFFOLK DOWNS

The BSC Group

Fig. 10

N

Horizontal Scale in Feet
NOT TO SCALE

MDC Property at Ocean Avenue (See Figure 11)

The bus route to Deer Island from the MDC property at Ocean Avenue would begin upon exiting the parking lot and turning right onto Ocean Avenue. Proceeding south on Ocean Avenue, the bus route would lead directly into Eliot Circle in Revere. The trip from Deer Island to the site is reversed; no changes in the bus route are required upon the return trip.

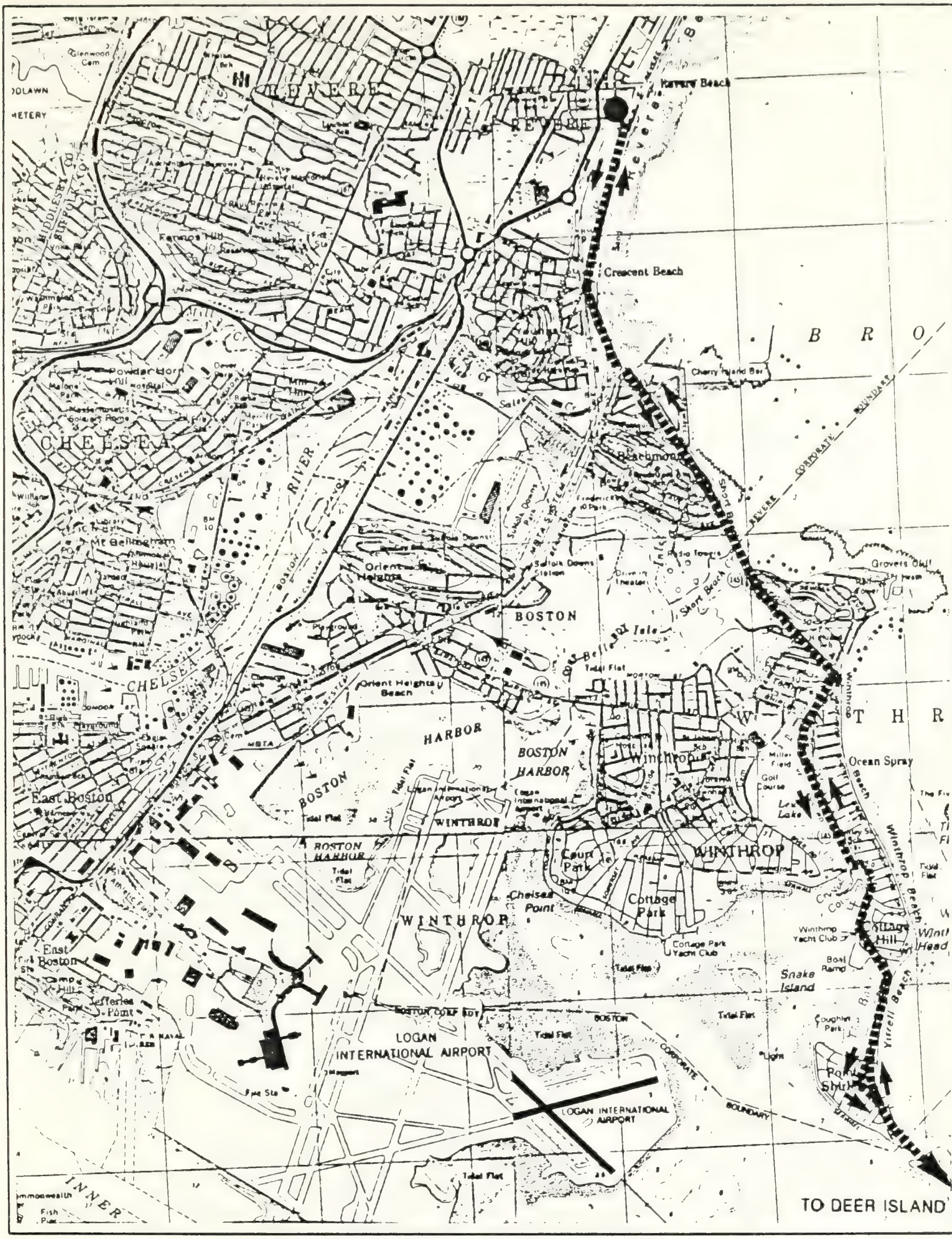
Wonderland MBTA Parking (See Figure 12)

The exit to North Shore Road from the existing MBTA parking lot is signalled to provide convenient entrances and exits from the site. Trips to Deer Island would begin by exiting onto North Shore Road and driving south to Butler Circle. From Butler Circle, buses would continue south on North Shore Road to Beach Street. At the intersection, which is signalled, a left turn is required onto Beach Street. The next right will bring the buses onto Ocean Avenue, an existing MBTA bus route. Ocean Avenue leads directly into Eliot Circle.

Return trips from Deer Island, via Eliot Circle, would follow the same route. From Ocean Avenue, buses would turn left onto Beach Street and then right onto North Shore Road. Right turns are regulated by a stop sign via a right turn access road, whereas vehicles travelling straight or left must obey the traffic light. Proceeding through Butler Circle, the route will follow North Shore Road back to the site entrance.

Towle Property/144 Addison Avenue (See Figure 13)

As stated in the description of candidate sites, the best bus route in terms of ease of access to the site would be via Bennington Street in East Boston. Using this route, buses exiting the site at Addison Avenue turn left. This



BUS ROUTE

MDC/ OCEAN AVENUE/ REVERE STREET

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Fig. 11

Horizontal Scale in Feet

NOT TO SCALE

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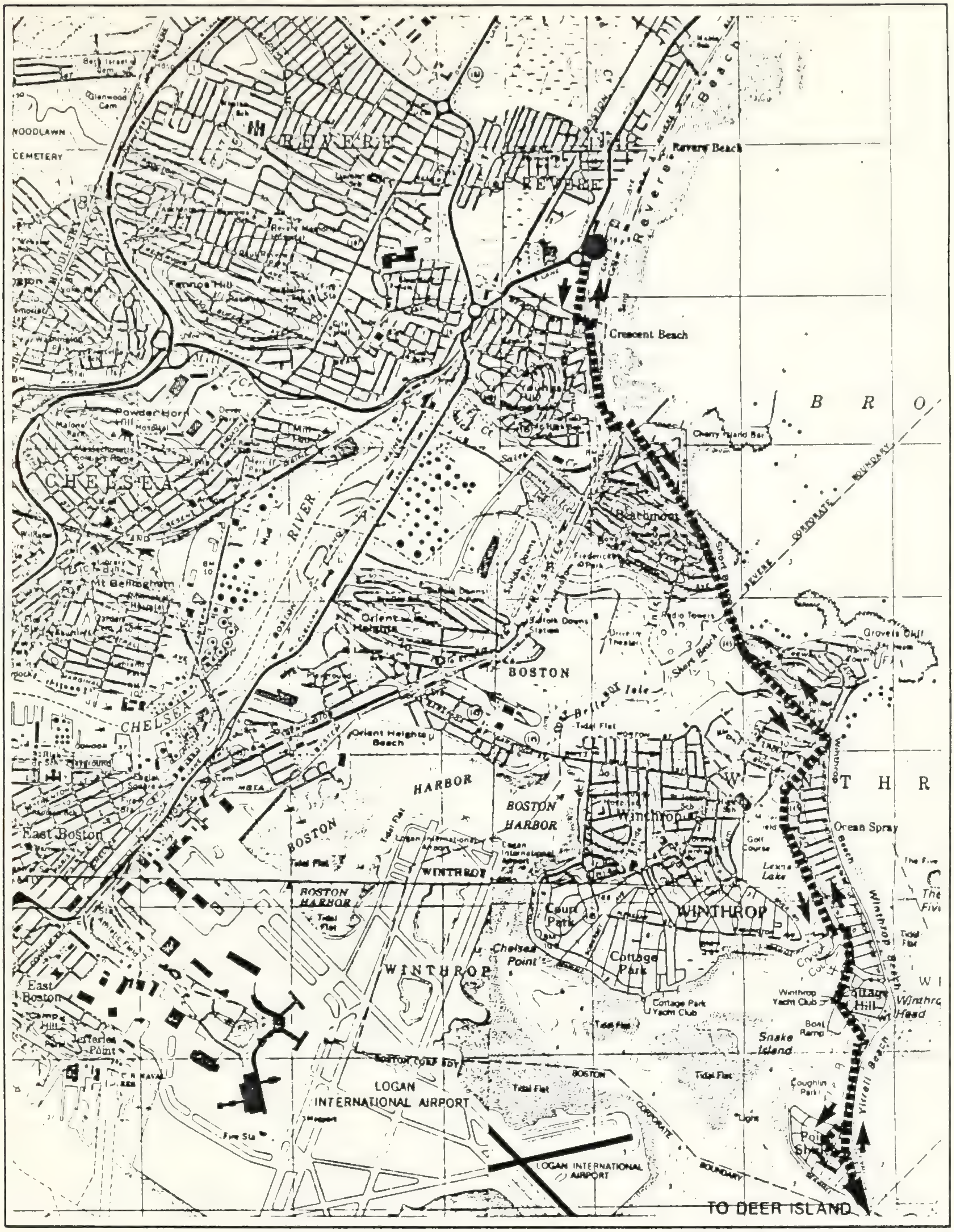

BUS ROUTE

MBTA WONDERLAND

The BSC Group

Fig. 12

Horizontal Scale in Feet
NOT TO SCALE

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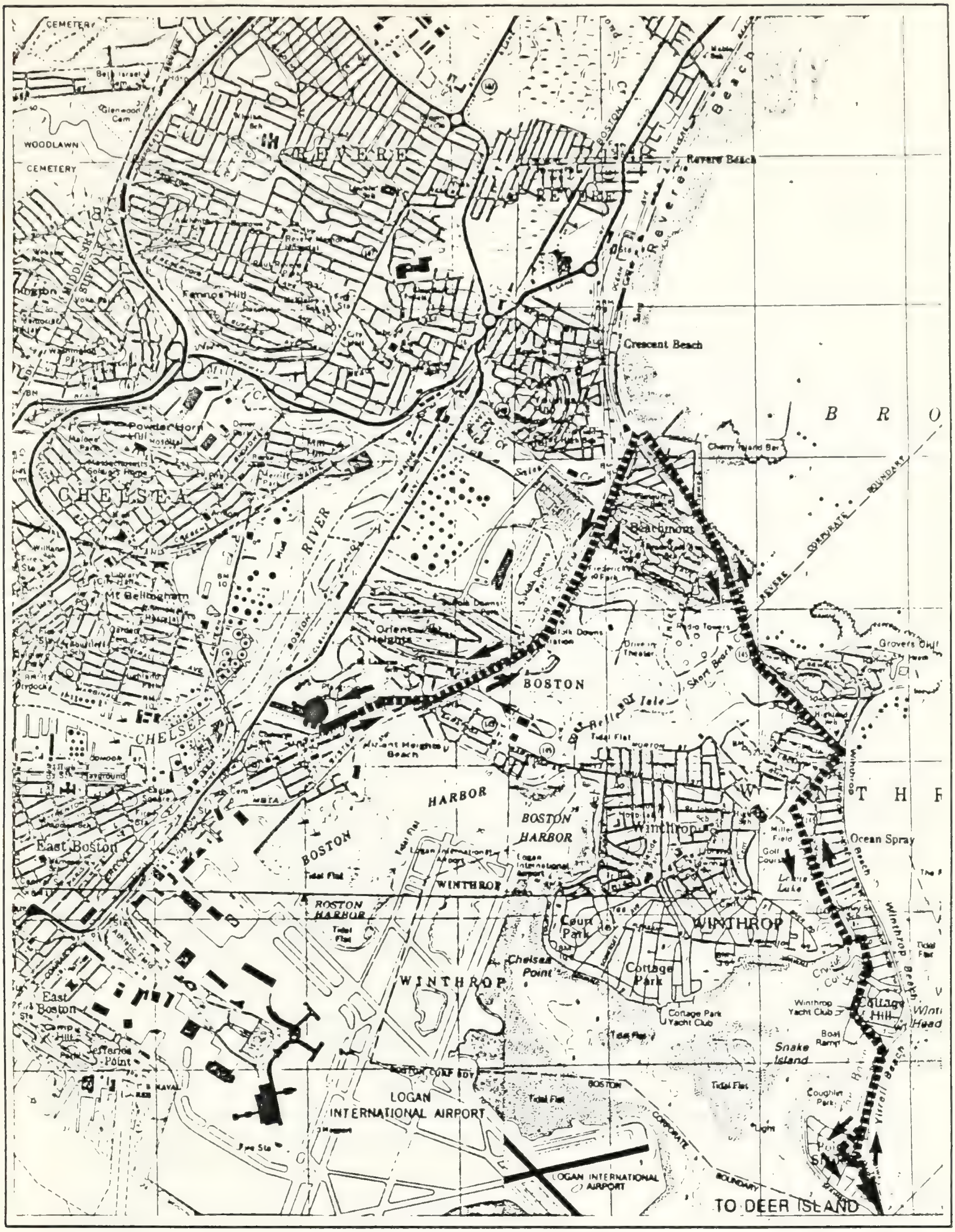


BUS ROUTE

TOWLE (144 ADDISON AVENUE)

The BSC Group

Fig. 13

Horizontal Scale in Feet
NOT TO SCALE

N

route leads to Saratoga Street. Buses continue on Saratoga Street until it intersects with Bennington Street. At its intersection with Winthrop Avenue, Bennington Street becomes State Road. The route continues straight directly into Eliot Circle in Revere. Return trips follow the same route in reverse.

Beachmont MBTA Parking (See Figure 14)

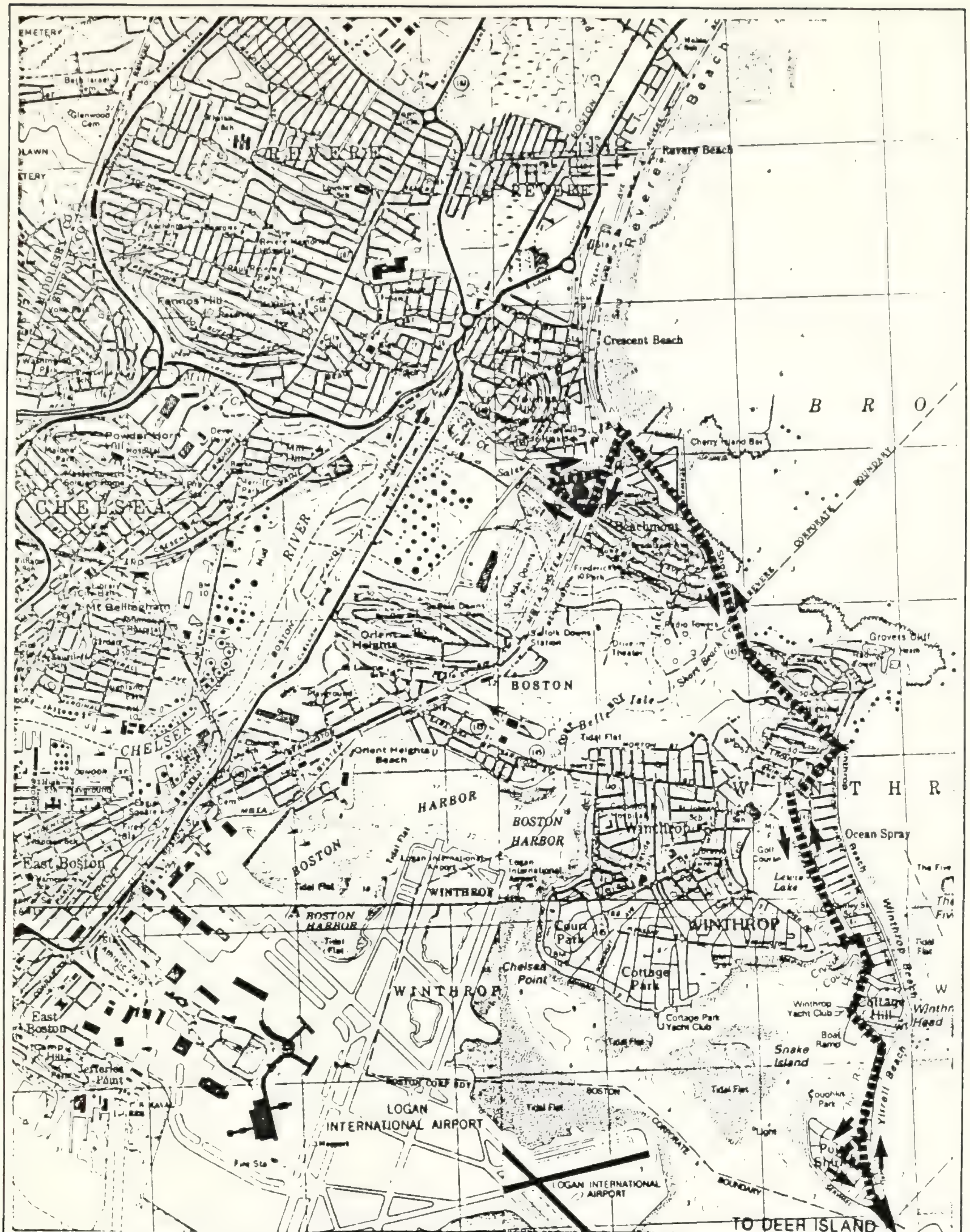
Winthrop Street provides access to enter and exit the existing surface lot at the Beachmont MBTA station. Based on the assumption that the parking lot access will remain in this location, buses from the site would turn right onto Winthrop Street, proceeding northwest. Approximately 500 feet from the parking lot, the road intersects with Route 145, at which point buses would turn right. Route 145 leads directly into Eliot Circle.

The return trip route from Deer Island, upon leaving Eliot Circle, travels under the Route 145 overpass and merges with State Road. Buses would turn right at the signalled intersection of State Road with Winthrop Avenue. The entrance to the Beachmont MBTA station is located approximately 500 feet after the intersection.

The route variation on the trip to and from Deer Island allows the bus route to avoid left turns in the Winthrop Avenue/State Road intersection, a source of potential traffic delays. A traffic island on State Road may also impede left turns. In addition, the travel through the majority of residential area on State Road is avoided by the routing of the buses directly onto Route 145 on the trip to Deer Island.

Parkway Plaza (See Figure 15)

The Parkway Plaza site provides direct access to the Revere Beach Parkway (Route 16) for the trip to Deer Island. The bus route to Deer Island would proceed east on Route 16. At



BUS ROUTE

BEACHMONT MBTA

The BSC Group

Fig. 14

Horizontal Scale in Feet

NOT TO SCALE

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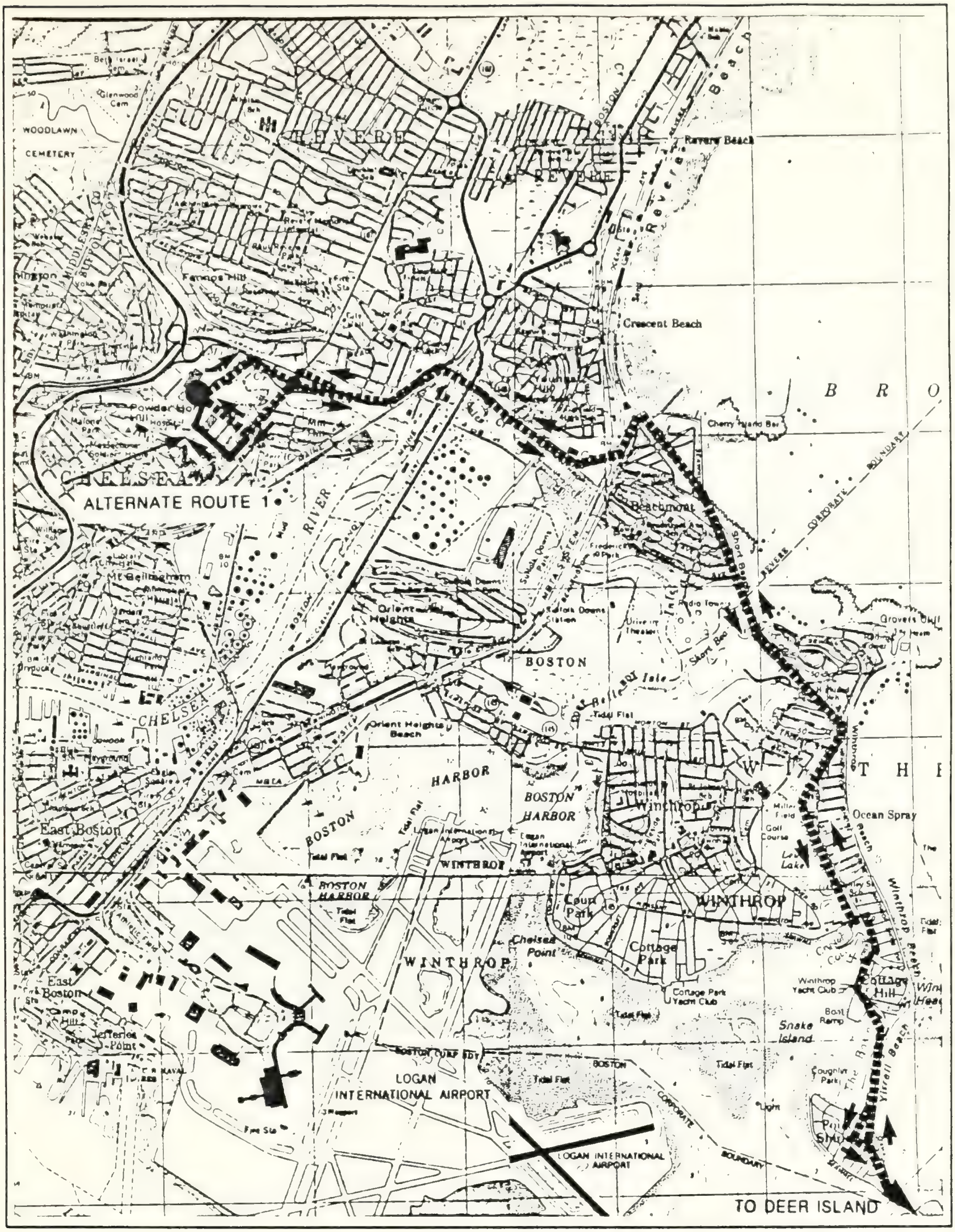


BUS ROUTE

PARKWAY PLAZA

The BSC Group

Fig 15

Horizontal Scale in Feet

NOT TO SCALE

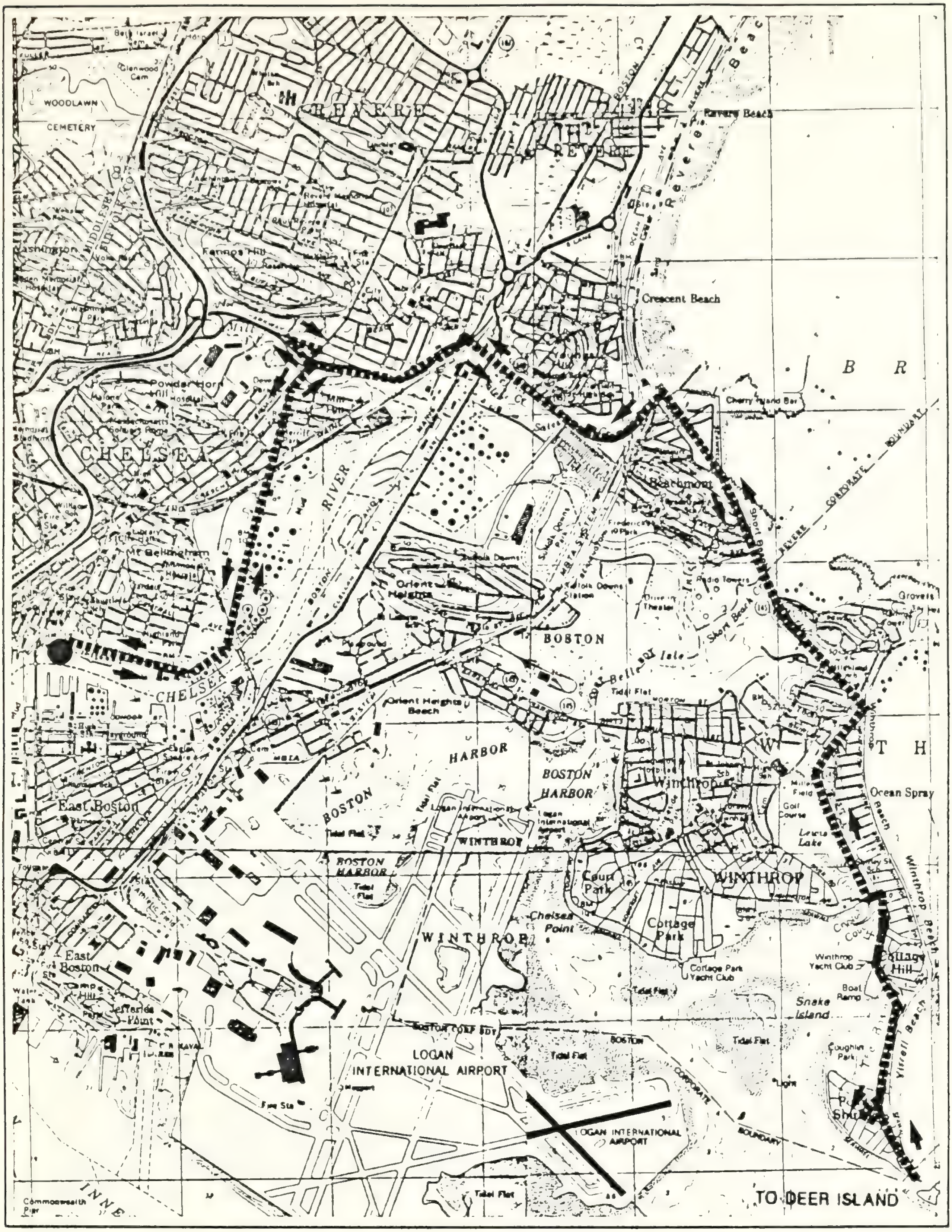
N

the signalled intersection of the Revere Beach Parkway and Route 145, buses would continue east on Route 145 to Eliot Circle in Revere.

Return trips from Deer Island would follow the same route with one exception. Because there is no direct access to Parkway Plaza when travelling westbound on the Revere Beach Parkway, buses would exit the Revere Beach Parkway at Broadway (Route 107). The buses could then be routed along two roads, Stockton Street or Webster Avenue, to get to Parkway Plaza. In the first case, the buses would travel approximately 1000 feet, then turn right at the intersection on Stockton Street. Stockton Street provides direct access to Parkway Plaza. Webster Avenue, in contrast, is located another 500 feet beyond Stockton Street. A more, well-travelled road than Stockton Street, Webster Avenue, nonetheless, requires the buses to travel a greater distance through a mixed residential/commercial area. Both streets are located at signalled intersections with Broadway.

<u>Eastern Minerals</u> (See Figure 16)

Marginal Street provides access to enter and exit the Eastern Minerals property. The bus route to Deer Island would follow Marginal Street to its intersection with Eastern Avenue. Buses would travel north along Eastern Avenue, until its intersection with Broadway. Approximately 500 to 1,000 feet after buses enter Broadway, an entrance ramp leads onto the Revere Beach Parkway. Then, the buses would follow the Revere Beach Parkway to Route 145 to Eliot Circle.



BUS ROUTE

EASTERN MINERALS

The BSC Group

Fig 16

Horizontal Scale in Feet
NOT TO SCALE

N

Site Development

For comparison it has been assumed that a 5.5-acre portion of the Parkway Plaza, Suffolk Downs, and Towle properties would be available for project parking. This would provide parking for approximately 800 cars and space for parking and loading/unloading of buses at each of these sites. It has been assumed that the Eastern Minerals site would be used in its entirety to provide space for approximately 549 cars. Adjacent property owned by Eastern Minerals would be used during peak years to provide up to an additional 127 spaces (for a total of 676 spaces). The available MDC land on Ocean Avenue near Revere Beach could provide surface parking for approximately 480 cars. A structured parking scenario would provide the required capacity during peak years of demand.

It has been assumed that structured parking would be required at the Beachmont MBTA and Wonderland MBTA sites as the existing surface parking lots are relatively small and are now used to capacity by MBTA commuters. For the purposes of comparison, it has been assumed that the MWRA would provide structured parking for 800 cars for a period of 15 years. The future disposition of the facilities would be negotiated with the MBTA. Site development would include demolition and clearance, paving, fencing and lighting to provide newly paved, well lighted and secure areas. A number of the sites are now paved to some degree but each would require varying degrees of additional grading and/or paving.

It has been assumed that there would be 24 hour, manned security at each site. Purchase was not considered to be a preferred option for any of the final seven sites.

Appendix

1

The BSC Group

Gillian H. Thomas
Consultant

Belle Isle
A Massachusetts Limited Partnership
Box 584, East Boston, Massachusetts 02128 • (617) 567-5500

March 10, 1988

Mr. Thomas Pelham
Director, Development Department
Massachusetts Water Resources Authority
100 First Avenue
Charlestown Navy Yard
Charlestown, MA 02129

Dear Mr. Pelham:

It was a pleasure meeting with you at Comunitas on February 16, 1988 to hear your presentation of the MWRA's need to provide automobile parking for workers during construction of the treatment facility at Deer Island.

Belle Isle Partnership is interested in exploring with the MWRA the possible lease of space at Suffolk Downs. I have instructed Antonio DiMambro of Comunitas to forward to you a locational plan of possible areas for discussion at Suffolk Downs which may address your needs. After you have reviewed this material, please feel free to contact me should you wish to pursue this possibility further.

Sincerely,

BELLE ISLE LIMITED PARTNERSHIP

Gillian H. Thomas

Gillian H. Thomas
Consultant

GHT/gmz

GHTgz/112.88

The Commonwealth of Massachusetts
Metropolitan District Commission
William J. Geary, Commissioner

20 Somerset Street
Boston, MA 02108
617-727-5114

March 8, 1988

The Metropolitan Network of Services

Parks

Beaches

Community Boating

Historic Sites

Recreational Facilities

Public Concerts

Trailside Museum

Boston Harbor Islands

Metropolitan Police

Flood Control

Watershed Management

Pure Water Supply

Quabbin, Wachusett and Sudbury Reservoirs

Franklin Park and Stone Memorial Zoos

Parkway, Boulevard and Bridge System

Charles, Mystic and Neponset Rivers

Beaver Brook, Blue Hills, Elm Bank, Breakheart, Middlesex Fells, and Stony Brook Reservations

Mr. Thomas Pelham
Director, Development Department
Mass. Water Resources Authority
Charlestown Navy Yard
100 First Avenue
Boston, MA. 02129

Dear Mr. Pelham:

I have reviewed your letter of February 23, 1988 relative to the possibility of a joint development effort between the MDC and the MWRA that would provide for interim shared use and both short and long-term physical and aesthetic improvements of two MDC sites, one near Wonderland Station and one adjacent to Revere Beach Parkway. There may well be mutual advantages to your proposal. While the MDC cannot commit to a joint development proposal at this time, we are prepared to participate in a joint review and analysis.

Your letter has been forwarded to our Planning Office with instructions to pursue the necessary studies with the MWRA. Mrs. Julia O'Brien at 727-9693, will coordinate this work for the Commission. I appreciate that the MWRA must adhere to a federal court-mandated schedule. We will cooperate in your effort to fulfill that mandate.

The MDC looks forward to working with the MWRA on this matter. If I can be of further assistance, please do not hesitate to contact me.

Sincerely yours,

WILLIAM J. GEARY
Commissioner

WG/ml

cc: J.O'Brien

MetroParks MetroParkways MetroPolice PureWater

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

James F. O'Leary
General Manager
Transportation Building
Ten Park Plaza
Boston, Massachusetts 02116

March 11, 1988

Mr. Thomas Pelham, Director
Development Department
Massachusetts Water Resources Authority
100 First Avenue
Boston, Massachusetts 02129

Dear ~~Mr. Pelham:~~ Tom,

I have reviewed your letter expressing an interest in the joint development of additional parking spaces on the Massachusetts Bay Transportation's property adjacent to the Wonderland and Beachmont Blue Line stations. While, at this time, it is too preliminary for the MBTA to commit to such a joint venture, I do concur with your request that we seriously explore the opportunity. The appropriate development of additional parking to serve our Blue Line commuters is a priority of the MBTA. If we can secure such parking in a manner that benefits the schedule and interests of the Massachusetts Water Resources Authority, as well as the MBTA, then certainly a shared approach to the development of such parking could be a wise use of public funds.

I am forwarding your request to Messrs. Keville and Steward in the Construction Department, with the instructions that they explore this opportunity. I understand that the MWRA's federal court schedule adds some urgency to your request. The MBTA will attempt to accommodate your schedule requirements within the constraints of existing resources.

Please contact either Mr. Francis Keville or Mr. Charles Steward at your earliest convenience to initiate the site-related analysis necessary to define the possible areas of joint development.

Pending the outcome of the analysis, I look forward to working with the MWRA on such joint development opportunities.

Sincerely,

JNOL

James F. O'Leary
General Manager

cc: F. M. Keville
C. B. Steward

D R A F T

Mr. Tom Pelham
Director, Development Department
Massachusetts Water Resources Authority
Charlestown Navy Yard
100 First Avenue
Boston, MA 02129

Dear Mr. Pelham:

Thank you for your letter of 2/25/88. I enjoyed meeting with you and discussing the future of any surplus land at the Parkway Plaza Shopping Center.

As we discussed, I am exploring options to further develop this property. However, your needs may be accomodated depending upon the MWRA's schedule, amount of land required, and flexibility on the location within the site. Consequently, I would like to continue to explore with you this opportunity. Please keep me informed as your needs and financial capabilities become more specific.

Sincerely,

Patrick Glynn

Patrick Glynn

WATER RESOURCES AUTHORITY
MASSACHUSETTS